

Pharma-D

| S. No.                               | Date | Title | Page No. | Teacher's Sign / Remarks |
|--------------------------------------|------|-------|----------|--------------------------|
| AKASH.HN PHARMA D 1ST YEAR MBC NOTES |      |       |          |                          |



10 mark important concepts



# ENZYMES

① Define an enzyme? Outline the IUB classification of enzyme with examples. Explain the mechanism of enzyme action. Enzymes are divided into six major class.

Ans: Enzymes are biocatalysts synthesized by living cells. They are protein in nature, colloidal, and thermolabile in character, and specific in their action.

① Oxidoreductases  
Alcohol dehydrogenase.

oxidation  $\rightarrow$  Reduction



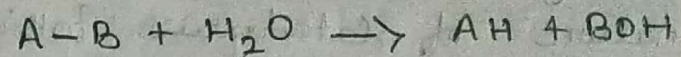
② Transferases  
Hexokinase.

group transfer



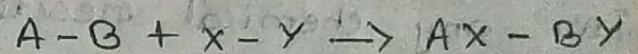
③ Hydrolases  
pepsin.

Hydrolysis



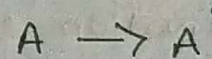
④ Lyases  
Aldolase

Addition  $\rightarrow$  Elimination



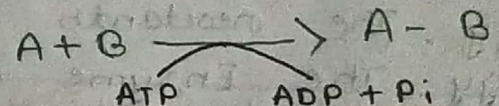
⑤ Isomerases  
phosphohexose isomerase

Interconversion of Isomers



⑥ Ligases  
Acetyl CoA carboxylase

Condensation



① oxidoreductases: Enzyme involved in oxidation-reduction reactions.

② Transferases: Enzyme that catalyse the transfer of functional groups.

③ Hydrolases: Enzyme that bring about hydrolysis of various compounds.

④ Lyases: Enzyme involved in addition or removal of  $H_2O$ , ammonia,  $CO_2$  etc.

⑤ Isomerase: Enzyme involved in Isomerization reaction.

⑥ Ligase: Enzyme that catalyses synthetic reactions.



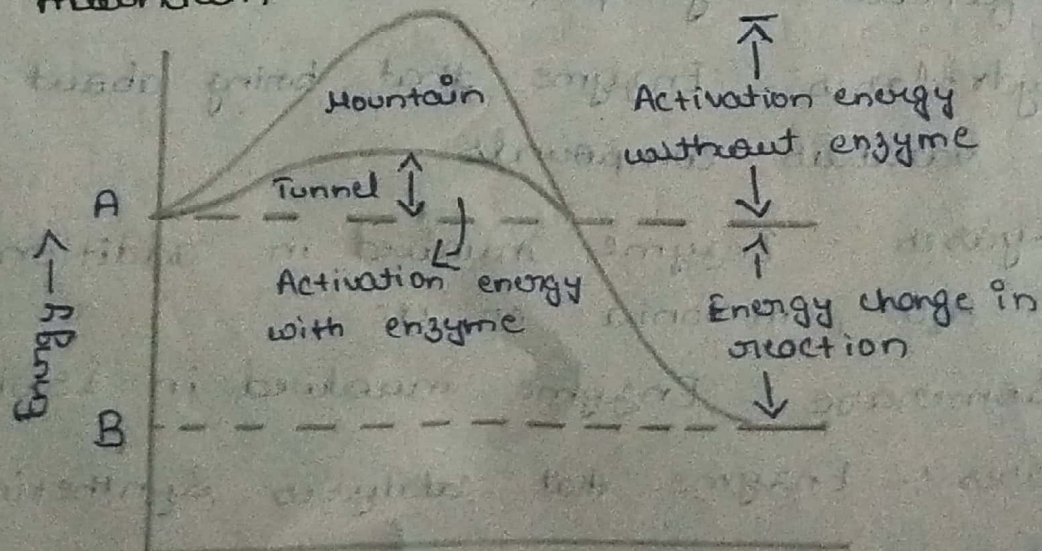
Each class further divided into many sub-classes. 'EC' number is assigned to each enzyme representing class (I digit), Sub-class (II digit), Sub-Sub class (III digit) and Individual Enzyme. Each Enzyme is given a specific name indicating the substrate, co-enzyme and the type of the reaction catalysed by the enzyme. IUB names for the enzymes are specific & unambiguous. They have not been accepted for general use as they are complicated. Therefore trivial names are commonly used & widely accepted.

### Mechanism of Enzyme Action

Catalysis is the prime function of enzymes. The nature of catalysis taking place in the biological system is similar to that of non-biological catalysis. For any chemical reaction to occur, the reactants have to be in an activated state.

**Enzyme lowers Activation energy** :- The energy required by the reactants to undergo the reaction is known as activation energy. The reactants when heated attain the activation energy. The Enzyme reduces the activation energy and cause reaction to proceed at lower temperature. Enzymes do not alter the equilibrium constants they only enhance the velocity of the reaction.

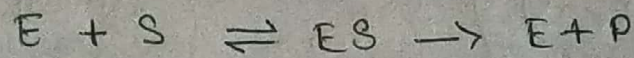
The role of enzyme is comparable with a tunnel made in a mountain to reduce the barrier.





## Enzyme - Substrate complex formation

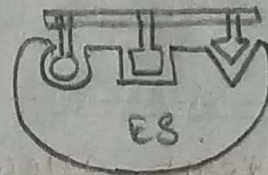
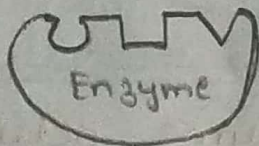
The prime requirement for enzyme catalysis is that the substrate must combine with the enzyme at the active site to form Enzyme-Substrate complex which ultimately results in the product formation.



Theories explaining Enzyme - Substrate complex formation

### ① Lock and Key model

This theory was proposed by Emil Fischer. According to this model, the structure or conformation of the enzyme is rigid. The substrate fits to the binding site just as key fits into the proper lock. Thus the active site of an enzyme is a rigid and pre-shaped template where only a specific substrate can bind. This model does not give any scope for the flexible nature of enzymes, hence the model totally fails to explain many facts of enzymatic reactions.



### ② Induced fit Theory

Kashland proposed a more acceptable and realistic model for enzyme-substrate complex formation. As per this model active site is not rigid and pre-shaped substrate binding site present at the nascent active site. The interaction of substrate with the enzyme induces a fit or conformation change in the enzyme, resulting in the formation of a strong substrate binding site. Further due to Induced fit, the appropriate amino acids of the enzymes are repositioned to form active site and bring about the catalysis.



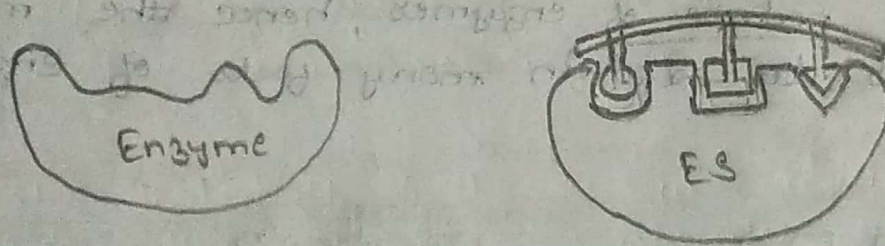
Induced fit model has sufficient experimental evidence from the x-ray diffraction studies. Koshland's model also explains the action of allosteric modulators and competitive inhibition on enzymes.



## ② Substrate Strain Theory

In this model, when a substrate binds to the active site, the enzyme induces strain to the substrate. The strained substrate leads to the formation of product.

In fact, a combination of the Induced fit model with the Substrate Strain is considered to be operative in the enzymatic action.

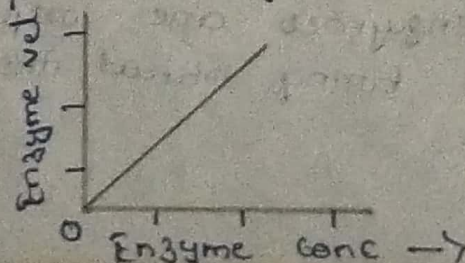


## ② Explain the factors affecting enzyme activity?

Add a note on the properties of Enzymes

### ① Concentration of enzyme

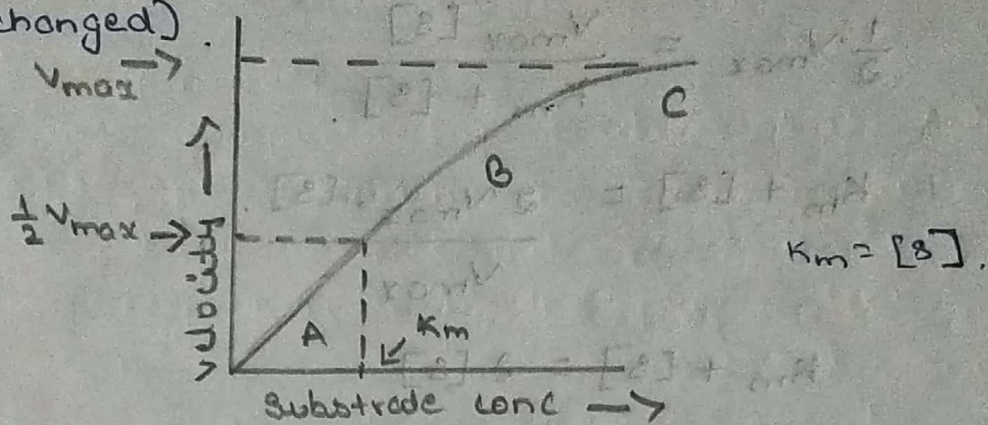
As the concentration of the enzyme is increased, the velocity of the reaction increases proportionally. This property of enzyme is made use in determining the serum enzymes for the diagnosis of disease. By using known volume of serum, and keeping all the other factors at the optimum level, the enzyme could be analysed in the laboratory.





## (i) Concentration of Substrate

Increase in the substrate concentration gradually increases the velocity of enzyme reaction within the limited range of substrate. A rectangular hyperbola is obtained when velocity is plotted against substrate concentration. The distinct phases of the reaction are observed in the graph (A-linear, B-curve, C-almost unchanged).



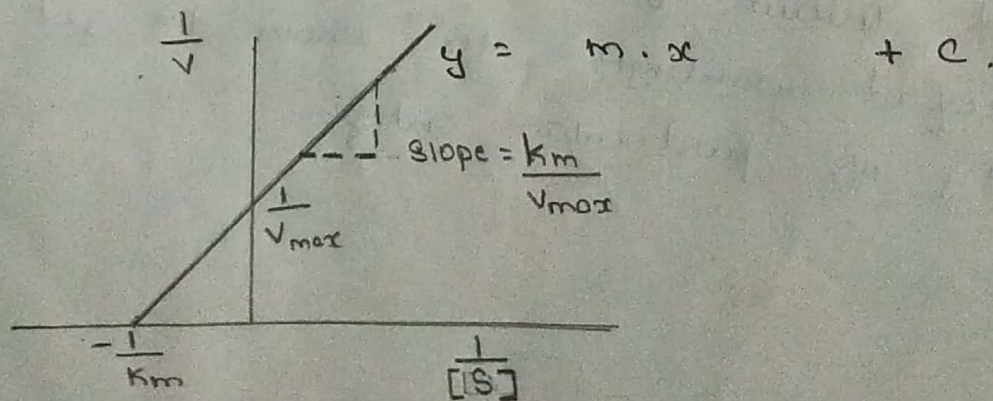
$K_m$  is defined as substrate conc to produce half maximum velocity in an enzyme catalysed reaction.

## (ii) Lineweaver double reciprocal plot

For the determination of  $K_m$  value, the substrate saturation curve is not very accurate, since  $V_{max}$  approached asymptotically. By taking reciprocal of the equation a straight line graphic representation is obtained.

$$V = \frac{V_{max} [S]}{K_m + [S]}$$

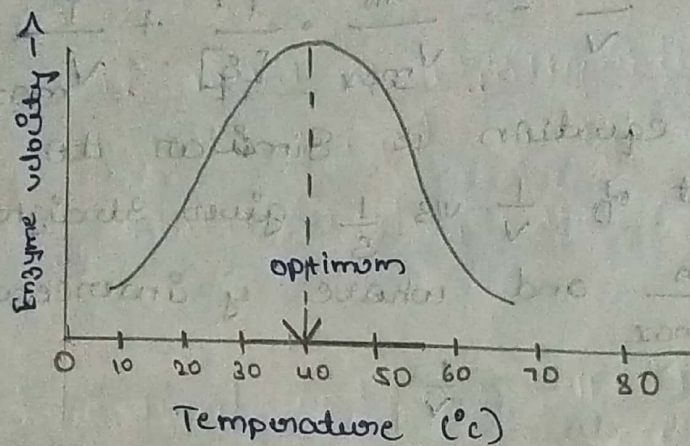
By taking reciprocal we get,  $\frac{1}{V} = \frac{K_m}{V_{max}} \cdot \frac{1}{[S]} + \frac{1}{V_{max}}$



It is much easier to calculate the  $K_m$  from the intercept on x-axis which is  $-\frac{1}{K_m}$ .



③ Effect of temperature  
velocity of an enzyme reaction increases with  
increase in temperature up to a maximum and then  
declines. A bell shaped curve is usually observed



Temperature coefficient ( $Q_{10}$ ) is defined as increase  
in enzyme velocity when the temperature is increased  
by  $10^{\circ}\text{C}$ . For a majority of enzymes,  $Q_{10}$  is between  
 $0^{\circ}\text{C}$  to  $40^{\circ}\text{C}$ . Increase in temperature results in  
higher activation energy of the molecules and more  
molecular collision and interaction for the reaction  
to proceed faster.

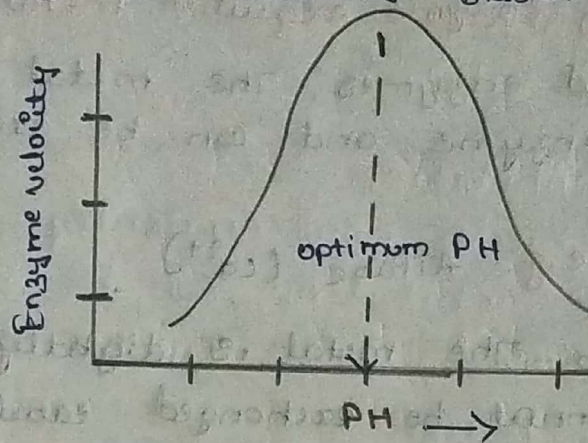
The optimum temperature for most of the  
enzymes is between  $40^{\circ}\text{C}$  -  $45^{\circ}\text{C}$ . Few enzymes active  
even at  $100^{\circ}\text{C}$ . Some plant enzymes like amylase  
have optimum activity around  $60^{\circ}\text{C}$ . This may be  
due to very stable structure and conformation of enzymes.



In general, when enzymes are exposed to a temperature above  $50^{\circ}\text{C}$ , denaturation takes place majority of the enzyme become inactive at higher temperature

#### ④ Effect of pH

Increase in the hydrogen ion concentration considerably influences the enzyme activity and a bell-shaped curve is usually observed.



Each Enzyme has an optimum pH at which the velocity is maximum. Below and Above this pH, the enzyme activity is much lower and at extreme pH, the enzyme becomes totally inactive.

Most of the enzymes of higher organisms show optimum activity around neutral pH (6-8). Enzymes from fungi and plants are most active in acidic pH (4-6).

Hydrogen ions influence the enzyme activity by altering ionic charges at active site.

#### ⑤ Effect of product concentration.

The accumulation of reaction products generally decreases the enzyme velocity. For certain enzymes, the products combine with the active site of enzyme and form a loose complex, and thus inhibit the enzyme activity. In the living system, this type of inhibition is generally prevented by a quick removal of product formed.



## ⑥ Effect of activators

Some of the enzyme require certain inorganic metallic cations like  $Zn^{2+}$ ,  $Na^+$ ,  $K^+$  etc. for their optimum activity. Metals function as activators of enzyme velocity through various mechanisms - combining with the substrate, formation of ES-metal complex, direct participation in the reaction and bringing a conformational change in the enzyme.

Two categories of enzyme requires metal for their activity

① metal-activated enzymes: The metal is not tightly held by the enzyme and can be exchanged easily with other ions

e.g.: ATPase ( $Ca^{2+}$ )

② metalloenzymes: The metal is tightly held by the enzyme and cannot be exchanged easily with other ions.

e.g.: Alcohol dehydrogenase ( $Zn$ )

## ⑦ Effect of Time

under ideal and optimal conditions, the time required for an enzyme reaction is less. Variation in the time of the reactions are generally related to the alterations in pH and temperature.

## ⑧ Effect of light and radiation

Exposure of enzymes to UV, beta, gamma, X-rays inactivates certain enzymes due to the formation of peroxides

eg: UV rays inhibit salivary amylase activity



## properties of Enzyme.

- ① All enzymes are protein in nature. The functional unit of enzyme is known as holoenzyme

Holoenzyme  $\longrightarrow$  Apoenzyme + Coenzyme  
(protein part) (non-protein)

- ②. Each Enzyme <sup>will</sup> catalyse only one particular reaction
- ③ Enzyme combines with substrate to form ES complex
- ④ only small amount of enzyme is needed to catalyse a lot of substrate
- ⑤ Enzymes are affected by change in temperature & pH.
- ⑥ Enzyme increases rate of reaction by lowering activation energy.
- ⑦ It only enhances rate of reaction doesn't shift the equilibrium.



③ Define Enzyme inhibition and discuss different types of enzyme inhibitions.

Ans:- Enzyme inhibitor is defined as a substance which binds with the enzyme and brings about a decrease in catalytic activity.

Types of enzyme inhibition.

①. Reversible Inhibition

②. Irreversible Inhibition

③. Allosteric Inhibition

① Reversible Inhibition

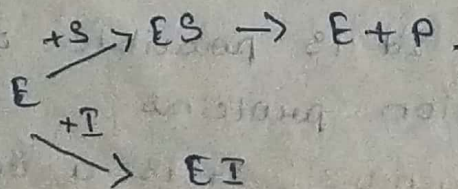
The inhibitor binds non-covalently with enzymes and the enzyme inhibition can be reversed if the inhibitor is removed. It is further divided into

① competitive inhibition

② non-competitive inhibition

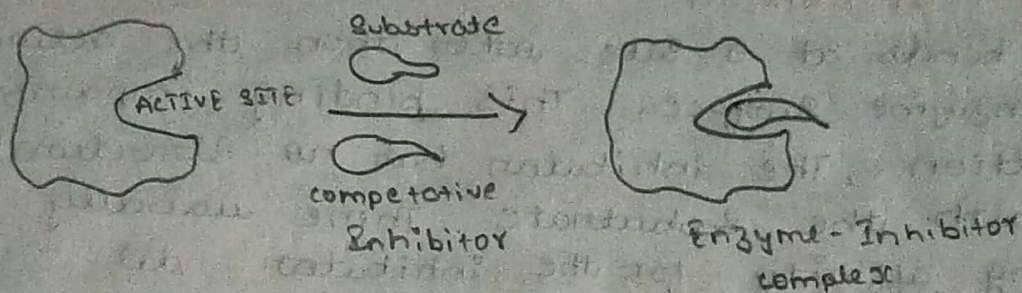
① competitive inhibition

The inhibitor which closely resembles the real substrate is regarded as substrate analogue. The inhibitor competes with substrate and binds at the active site of the enzyme but does not undergo any catalysis. As long as the competitive inhibitor holds the active site, the enzyme is not available for the substrate to bind.

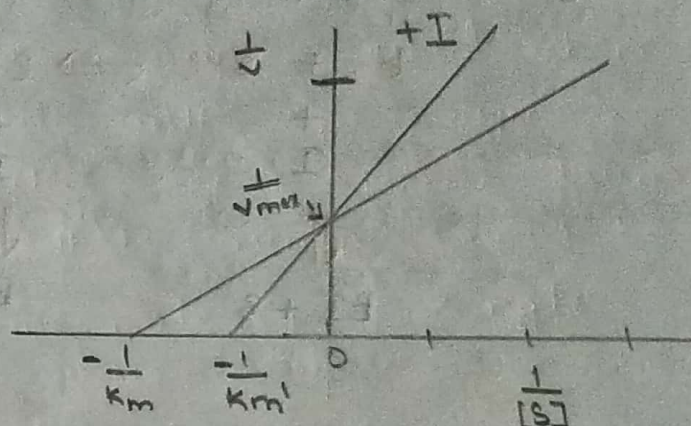
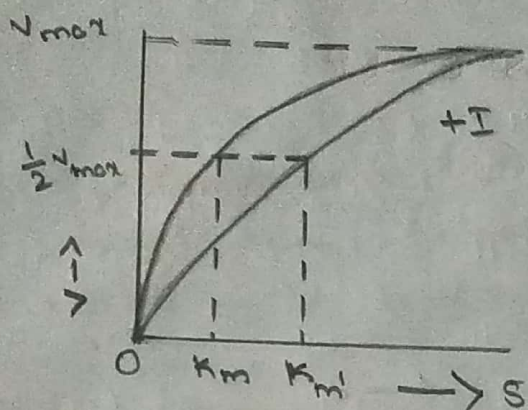


The relative concentration of the substrate and inhibitor and their respective affinity with the enzyme determines the degree of competitive inhibition. The inhibition could be overcome by a high substrate concentration.

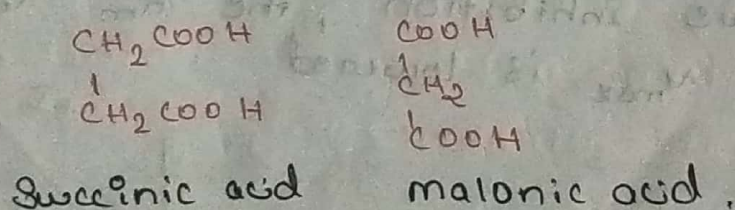




In competitive inhibition, the  $K_m$  value increases whereas  $V_{max}$  remains unchanged.



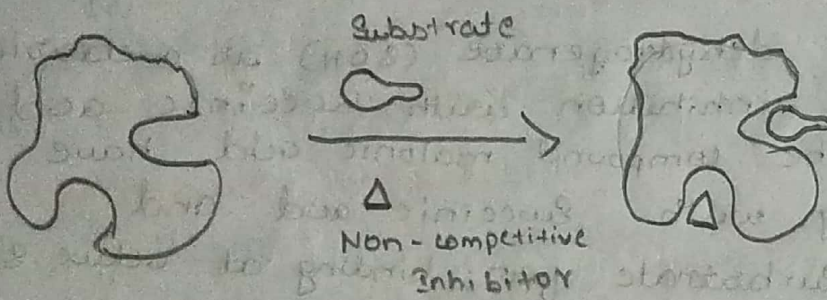
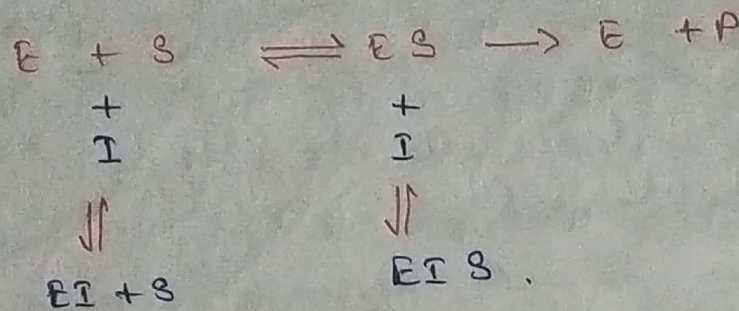
The enzyme Succinate dehydrogenase (SDH) is a classical example of competitive inhibition with succinic acid as its substrate. The compound malonic acid has structural similarity with succinic acid and competes with the substrate for binding at active site.



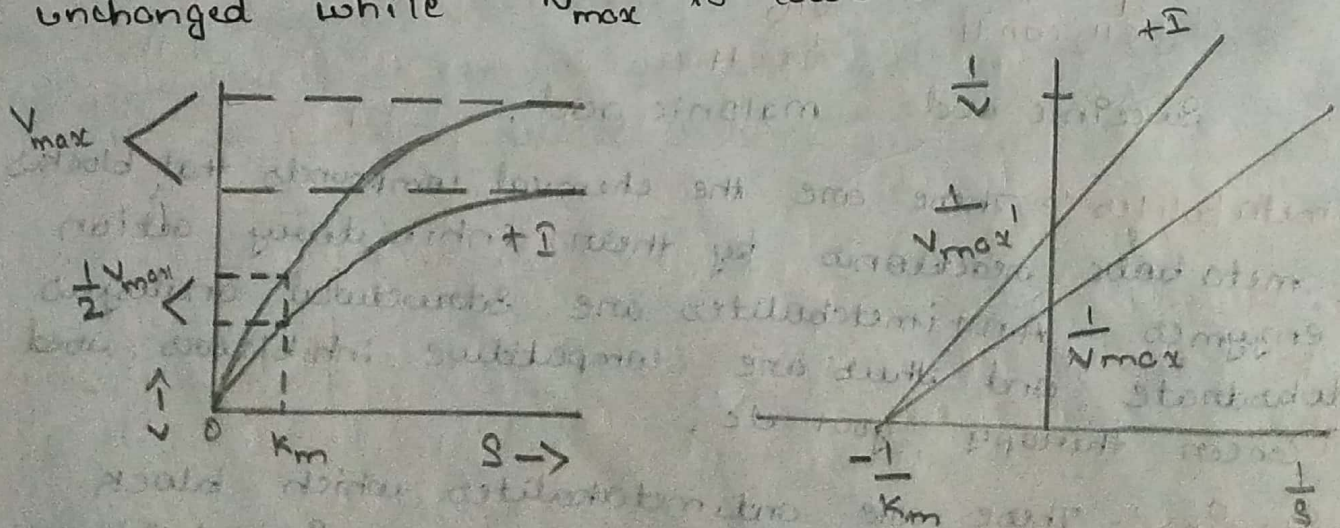


## ② Non-competitive Inhibition:

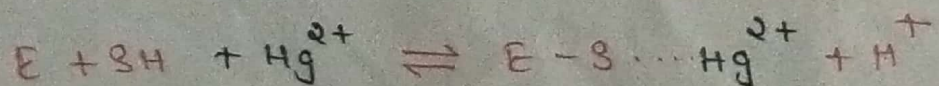
The inhibitor binds at a site other than the active site on the enzyme surface. This binding impairs the enzyme function. The inhibitor has no structural resemblance with the substrate. There usually exists a strong affinity for the inhibitor to bind at the second site. Inhibitor does not interfere with the enzyme-substrate binding. But the catalysis is prevented.



In non-competitive inhibition, the  $K_m$  value is unchanged while  $V_{max}$  is lowered.



Heavy metal ions like  $Hg^{2+}$  bind non-competitively inhibit the enzymes by binding with cysteinyl sulphhydryl groups.



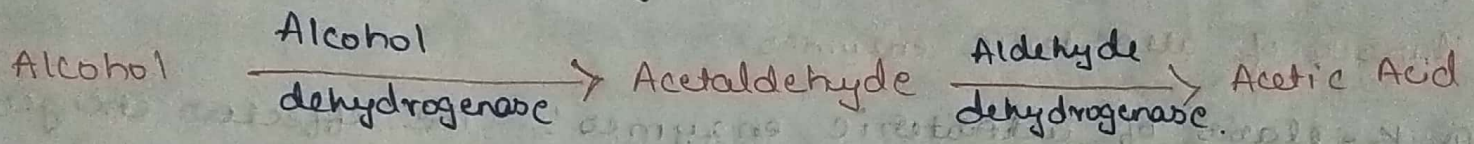


## ② Irreversible Inhibition

The inhibitors bind covalently with the enzyme and inactivate them, which is irreversible. These inhibitors are usually toxic poisonous substances.

① diisopropyl fluorophosphate (DFP) is a nerve gas developed by the Germans during Second World War. DFP irreversibly binds with enzyme containing serine.

② Disulfiram is a drug used in the treatment of alcoholism. It irreversibly inhibits the enzyme aldehyde dehydrogenase. Alcohol addicts, when treated with disulfiram, become sick due to the accumulation of acetaldehyde leading to Alcohol Avoidance.



③ penicillin antibiotics irreversibly bind with enzyme containing serine, and block the bacterial cell-wall synthesis.



### ③ Allosteric Inhibition

Some of the enzymes possess additional sites known as allosteric sites beside the active site. Such enzymes are known as allosteric enzymes.

**Allosteric effectors:-** Allosteric effector binds to the allosteric site and regulate the enzyme activity. The enzyme activity is increased when positive allosteric effector binds at the allosteric site known as activation site.

The enzyme activity is decreased when negative allosteric effector binds at the allosteric site known as Inhibition site.

#### Classes of allosteric enzymes

① **K-class of allosteric enzymes:-** The effector changes  $K_m$  and not the  $N_{max}$ , Double reciprocal plots, similar to competitive inhibition are obtained.

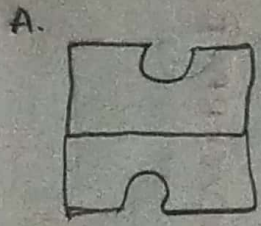
② **V-class of allosteric enzymes:-** The effector changes  $V_{max}$  and not the  $K_m$ , Double reciprocal plots resembles that of non-competitive inhibition.

#### Conformational change in allosteric enzymes

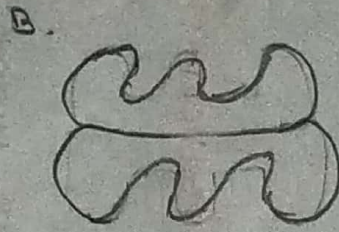
① Allosteric enzymes exists in two conformational states T and R

② T and R states are in equilibrium.

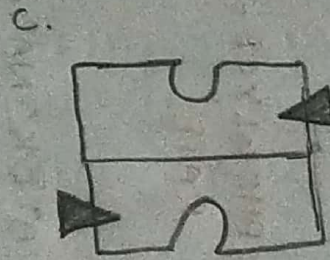




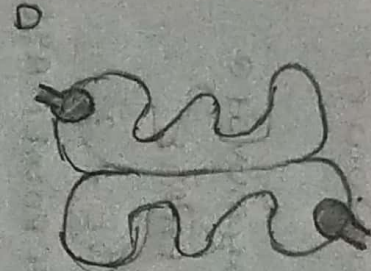
T form



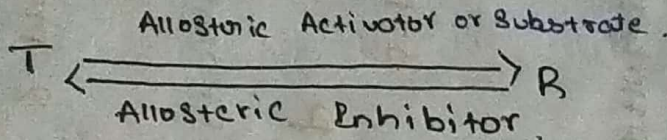
R-form



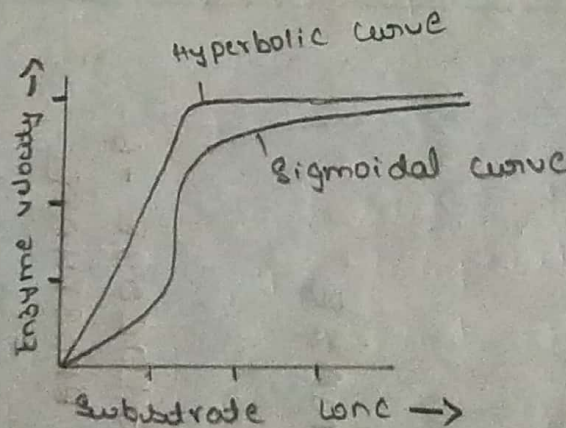
Effect of  
allosteric  
Inhibitor



Effect of  
allosteric  
activator



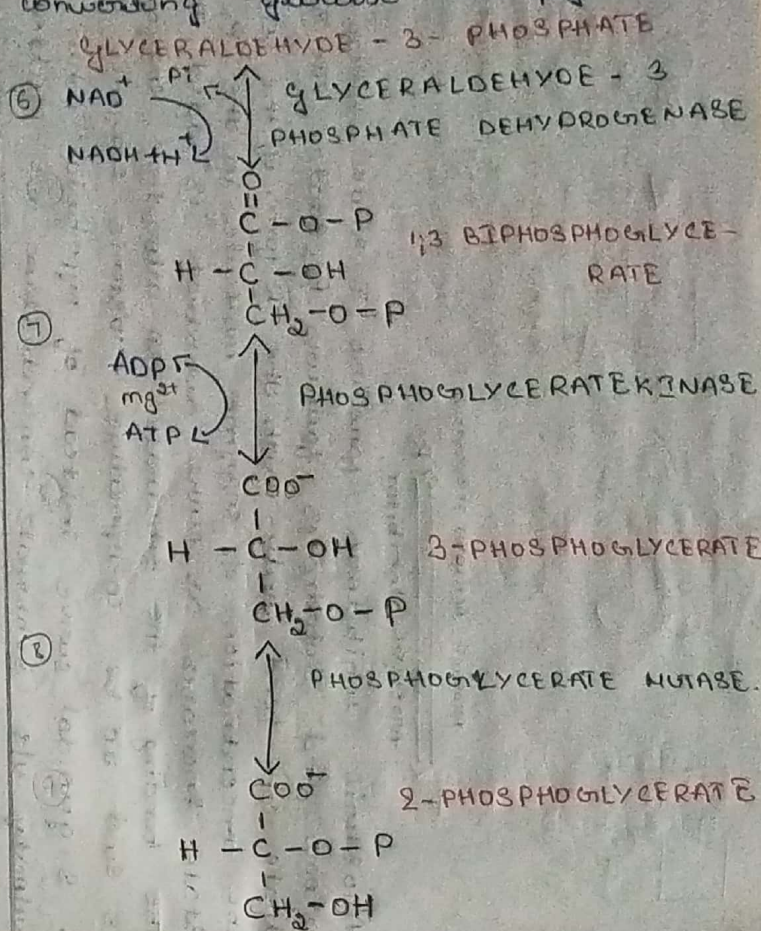
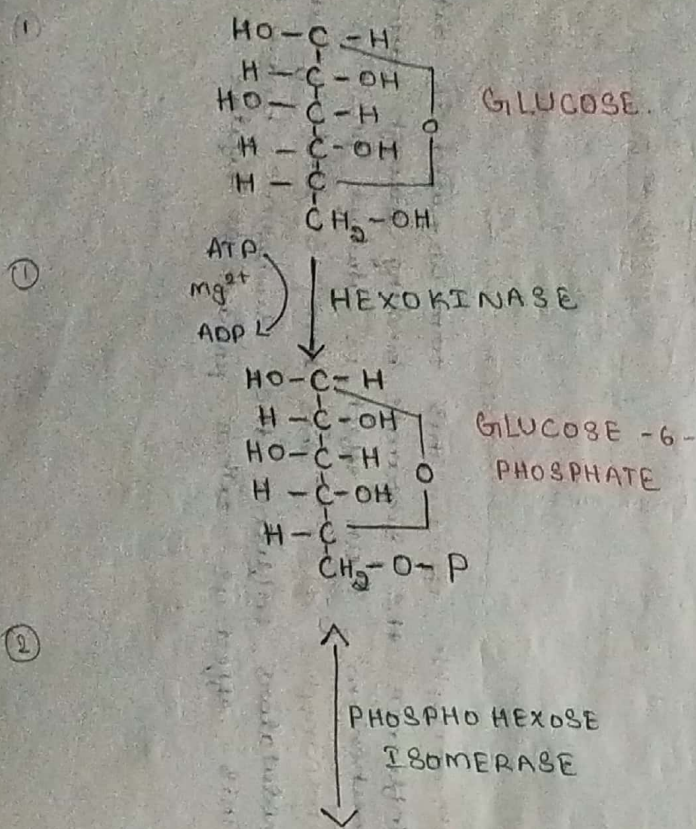
Allosteric Inhibitors favours T state whereas activators and substrates favours R state. The substrate can bind only with the R form of the enzyme. The concentration of enzyme molecule in the R state increases as more substrate is added, therefore ~~the binding of the substrate to allosteric enzyme~~ is said to be ~~co-operative~~. Allosteric enzymes gives a sigmoidal curve instead of hyperbola when the velocity v/s substrate concentration are plotted.





Q) Define glycolysis? Describe the biochemical pathway for the breakdown of glucose to pyruvate and lactate, write about energetics.

Ans: It is a metabolic process of converting glucose into pyruvate with the production of ATP.





Broccoli Ground mutton thraus Fresh Fruit Dish and no By  
 Picking Pumpkins do PomEare Pies

HE Put the PHONE And TRIed to Get the Plate to Eat Pie.  
 Plastic

### ① Energy Investment phase

- ① Glucose is phosphorylated to glucose-6-phosphate by hexokinase. This is an irreversible reaction, dependent on ATP and  $Mg^{2+}$ .
- ② Glucose 6 phosphate is impermeable to the cell membrane. It is a central molecule with a variety of metabolic fates - glycolysis, gluconeogenesis, glycogenesis.
- ③ Glucose-6-phosphate undergoes isomerization to give fructose-6-phosphate in the presence of the enzyme phosphohexose isomerase and  $Mg^{2+}$ .
- ④ Fructose-6-phosphate is phosphorylated to fructose 1,6-bisphosphate by phosphofructokinase. This is irreversible and regulatory step in glycolysis.

### ② Splitting phase

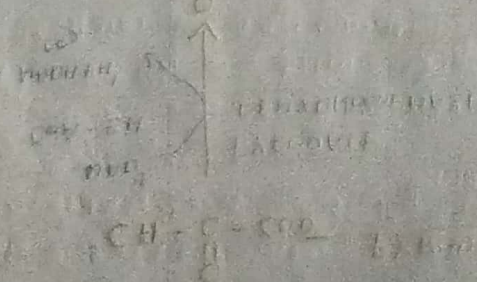
- ① Fructose 1,6-bisphosphate split to dihydroxyacetone phosphate and glyceraldehyde-3-phosphate by the enzyme aldolase.
- ② The enzyme triose phosphate isomerase catalyses the reversible interconversion of glyceraldehyde-3-phosphate & dihydroxyacetone phosphate.

### ③ Energy generation phase

- ① Glyceraldehyde 3-phosphate dehydrogenase converts glyceraldehyde-3-phosphate to 1,3-bisphosphoglycerate. It involved in formation of  $NADH + H^+$ .
- ② The enzyme phosphoglycerate kinase act on 1,3-bisphosphoglycerate resulting in the formation of 3-phosphoglycerate and ATP.
- ③ 3-phosphoglycerate is converted to 2-phosphoglycerate by phosphoglycerate mutase. This is an isomerization reaction.
- ④ The high energy compound phosphoenolpyruvate is generated from 2-phosphoglycerate by the Enzyme Enolase.

Anaerobic condition :- 2 ATP are synthesized  
 Aerobic condition :- 8 or 6 ATP are synthesized

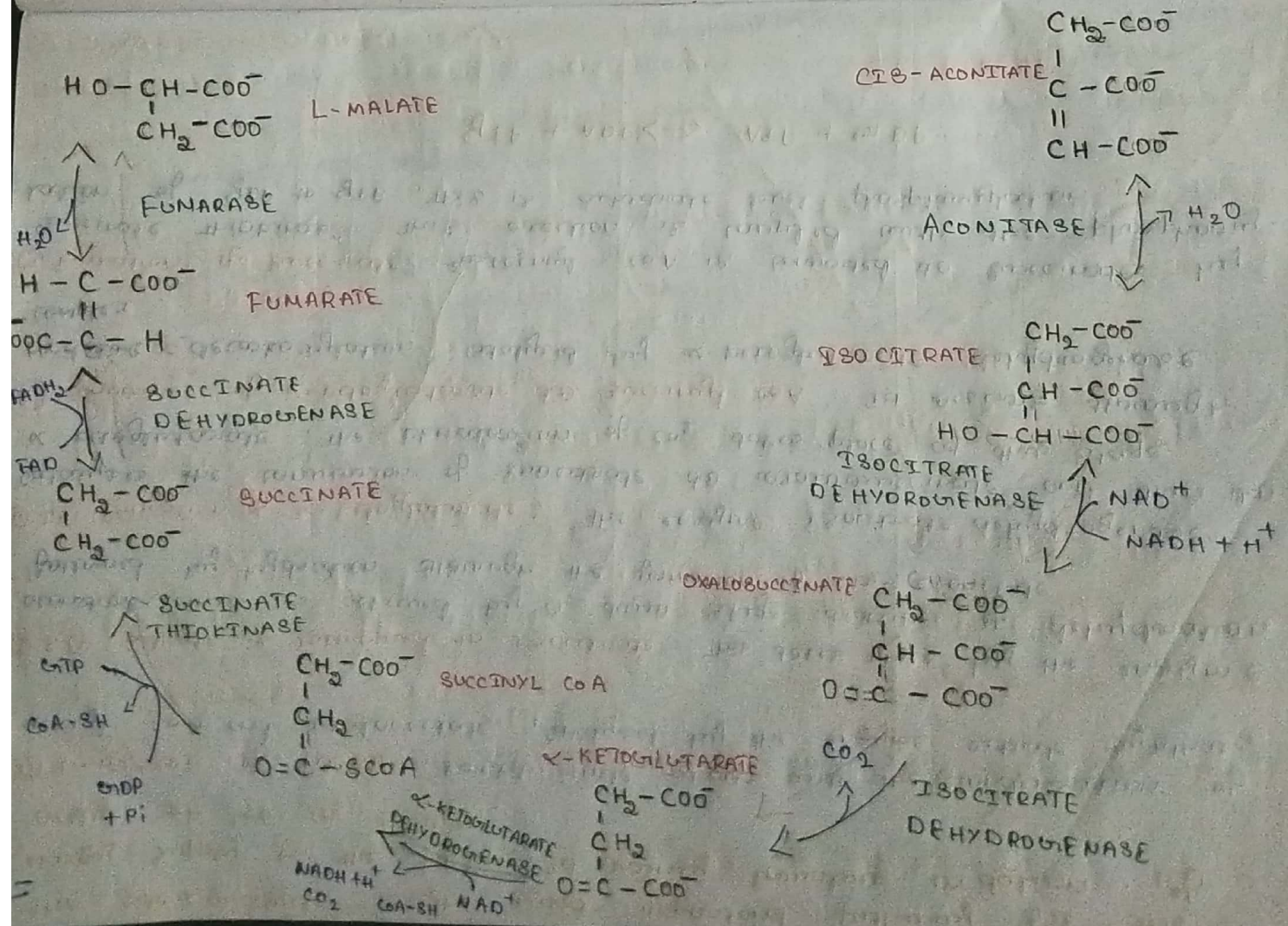
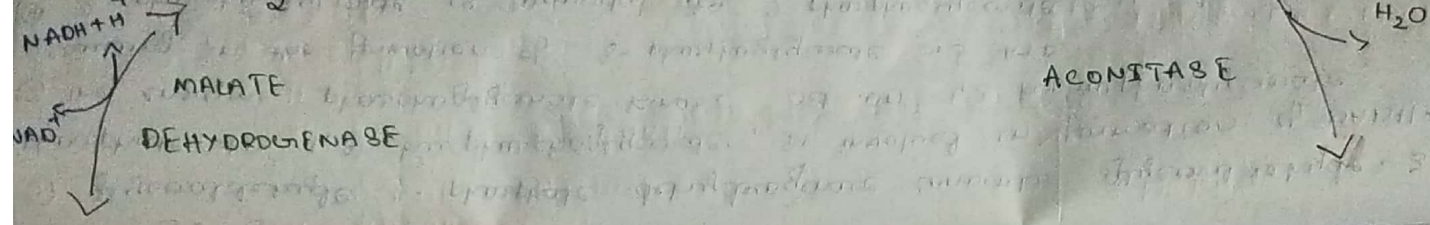
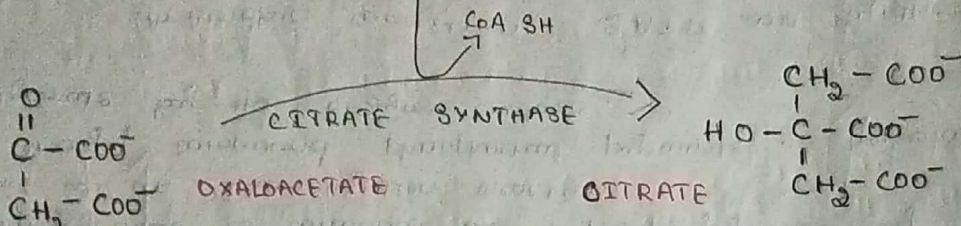
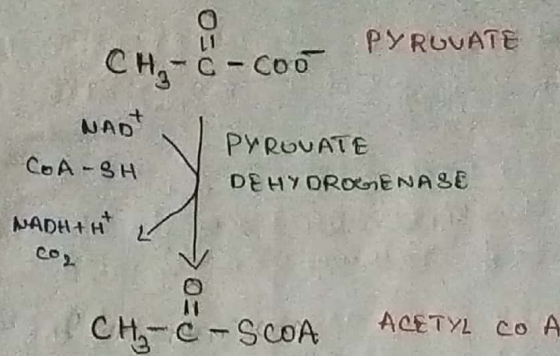
Site: All cells of the body





5) Explain the reaction sequence, significance and energetics of TCA cycle

Own  
 Given  
 City  $\rightarrow$   $H_2O$  X  
 Is  $\rightarrow$   $H_2O$   $\checkmark$   
 O  $\rightarrow$   $H_2$   $\checkmark$   
 Kept  $\rightarrow$   $CO_2$  X  
 Safe  $\rightarrow$   $SCoA$   $\checkmark$   
 &  
 Secure  $\rightarrow$   $COO$   $\checkmark$   
 From  $\rightarrow$   $H_2$  X  
 Molecular  $\rightarrow$   $H_2O$   $\checkmark$   
 $\rightarrow$   $H_2$  X  
 $\checkmark$   $\checkmark$   $\checkmark$   
 C A K S F M . A





The Citric Acid Cycle is the most important pathway for the energy supply to the body. It mainly involves oxidation of Acetyl CoA to  $\text{CO}_2$  &  $\text{H}_2\text{O}$ .

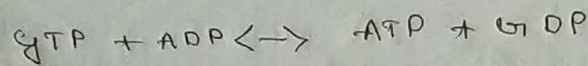
① Formation of Citrate: Krebs cycle starts with the condensation of acetyl CoA and oxaloacetate, catalysed by the enzyme citrate synthase.

② & ③ Citrate is isomerised to Isocitrate. This takes place by the enzyme aconitase. This is achieved by a two stage reaction of dehydration followed by hydration through the formation of cis-aconitate.

④ & ⑤ Formation of  $\alpha$ -ketoglutarate: The enzyme Isocitrate dehydrogenase catalyses the conversion of Isocitrate to oxalosuccinate and then to  $\alpha$ -ketoglutarate. The liberation of  $\text{CO}_2$  takes place at this stage.

⑥ Conversion of  $\alpha$ -ketoglutarate to Succinyl CoA: It occurs through oxidative decarboxylation catalysed by  $\alpha$ -ketoglutarate dehydrogenase complex.

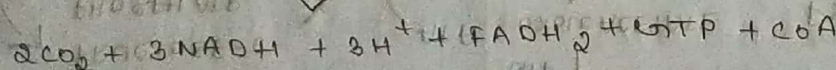
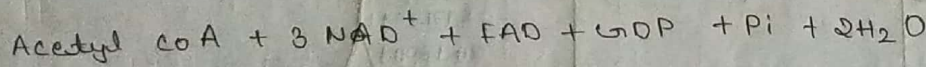
⑦ Formation of Succinate: Succinyl CoA is converted to Succinate by Succinate thiokinase. This reaction is coupled with the phosphorylation of GDP to GTP. This is substrate level phosphorylation.



⑧ Conversion of Succinate to Fumarate: Succinate is oxidised by Succinate dehydrogenase to fumarate. This results in production of  $\text{FADH}_2$ .

⑨ Formation of malate: The enzyme fumarase catalyses the conversion of fumarate to malate with addition of  $\text{H}_2\text{O}$ .

⑩ Conversion of malate to oxaloacetate: Malate is then oxidised to oxaloacetate by malate dehydrogenase. The oxaloacetate is regenerated, which can combine with another molecule of acetyl CoA and continue the cycle.



A total of 12 ATP are produced from one acetyl CoA.

Significance:

- ① It brings about complete & final oxidation of acetyl CoA in aerobic respiration.
- ② It produces simple and harmless end product such as  $\text{CO}_2$  &  $\text{H}_2\text{O}$ .
- ③ TCA cycle produces many important i.e., 12 organic acids as the intermediates during the process.

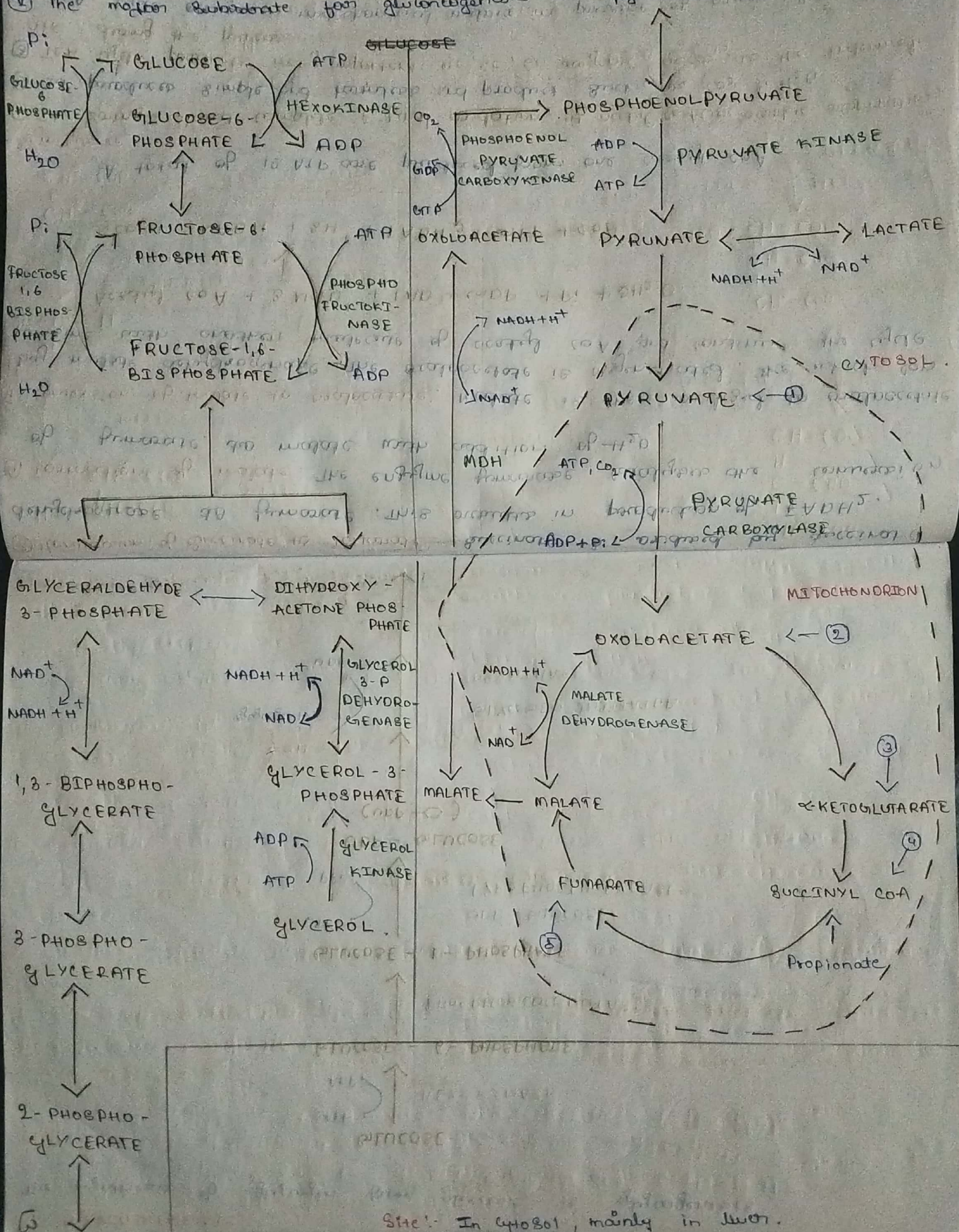
④ TCA cycle occurs in mitochondrial matrix in presence of oxygen. Thus it takes place only in aerobes.

⑤ It is the major source of energy supply to the body.

Site: mitochondrial matrix



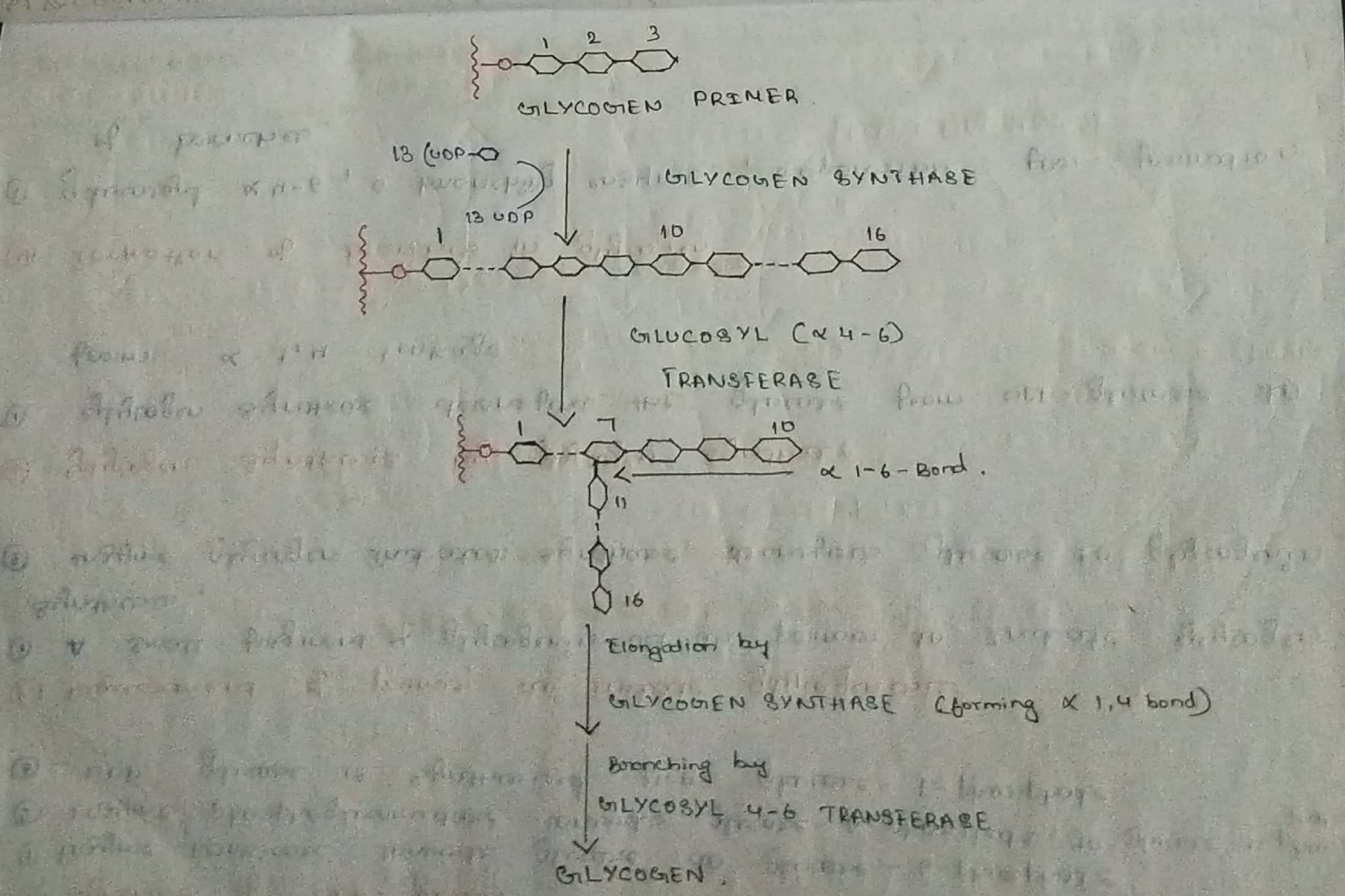
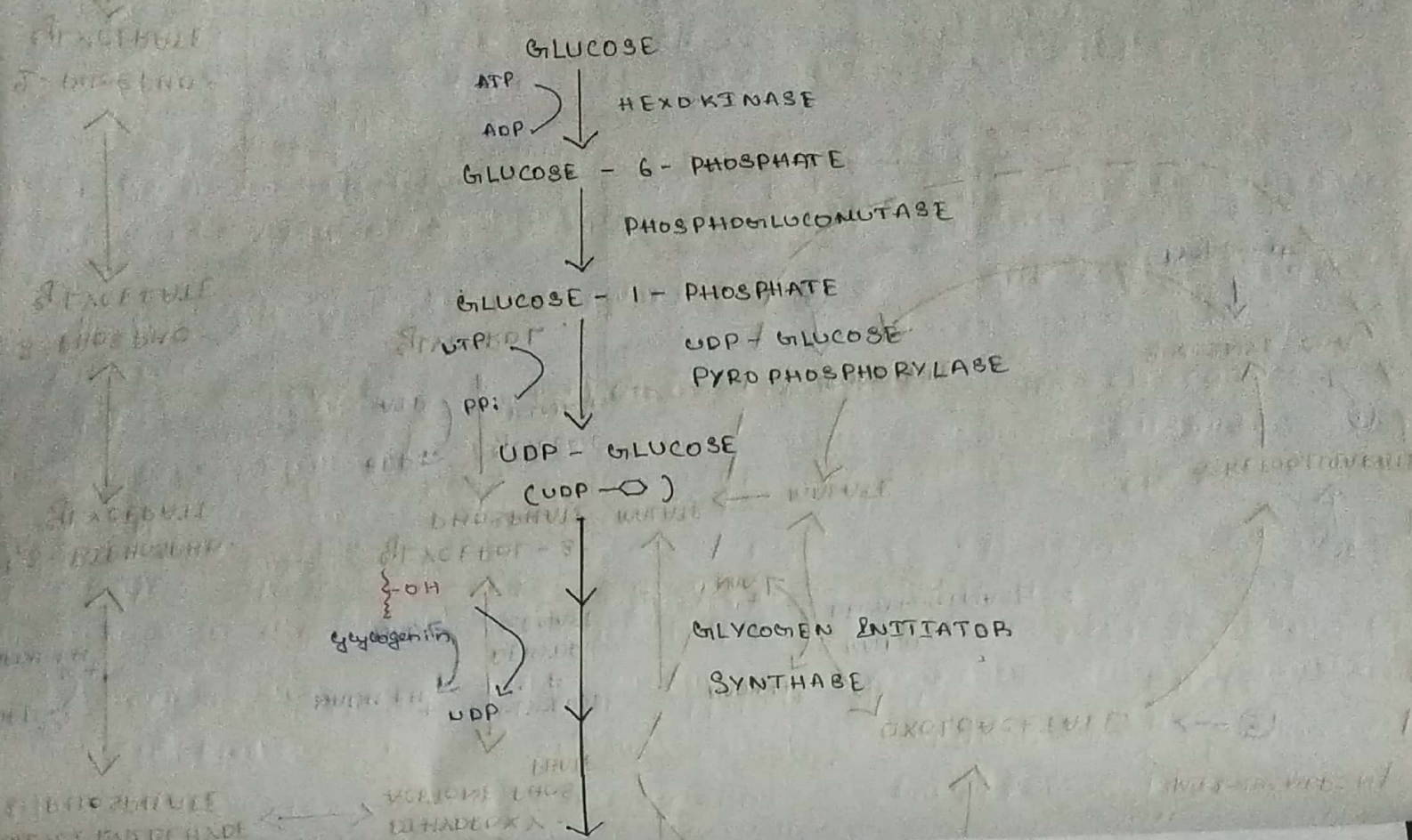
- 6) Explain gluconeogenesis? Explain its significance.
- Ans: It is a metabolic process which involves synthesis of glucose from non-carbohydrate compound.
- 7) The major substrate for gluconeogenesis are pyruvate, lactate, glycerol





# GLYCOGENESIS

The synthesis of glycogen from glucose is glycogenesis.





Ans:

- ① Synthesis of UDP-glucose
- ① Enzyme hexokinase converts glucose to glucose-6-phosphate
- ② Enzyme phosphoglucomutase converts glucose-6-phosphate to glucose-1-phosphate
- ③ UDP glucose is synthesized from glucose-1-phosphate

## ② Requirement of primers to initiate glycogenesis

- ① A small fragment of glycogenin act as 'primer' to initiate glycogen synthesis
- ② enzyme glycogen Initiator Synthase transfers glucose to glycogenin

## ③ glycogen synthesis by glycogen synthase

- ① glycogen synthase transfers the glucose from UDP-glucose to form  $\alpha$ -1,4 linkage

## ④ Formation of branches in glycogen

- ① glucosyl  $\alpha$ -4-6, a branching enzyme, responsible for formation of branches

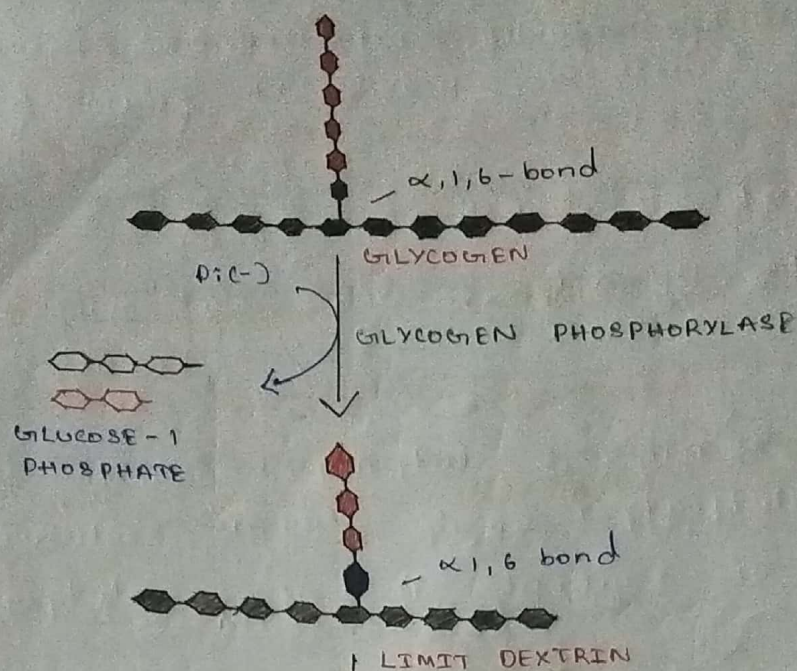
⑤ Glycogen is further elongated & branched respectively, by the enzyme glycogen synthase & glucosyl  $\alpha$ -4-6 transferase

Site: cytosol

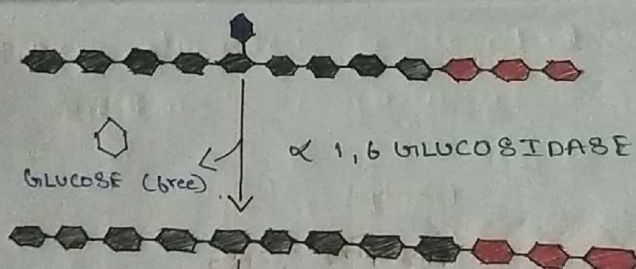


## ⑧ GLYCOGENOLYSIS

It is a metabolic pathway which involves degradation of glycogen to give glucose.



TRANSFERASE [debranching enzyme]



PHOSPHORYLASE

GLUCOSE-1-PHOSPHATE

PHOSPHOGLUCOMUTASE

GLYCOLYSIS.  $\leftarrow$  GLUCOSE-6-PHOSPHATE

GLUCOSE-6-PHOSPHATASE

GLUCOSE



### ① Action of glycogen phosphorylase

- ① The  $\alpha$  1,4-glycosidic bonds are cleaved sequentially by the enzyme to yield glucose-1-phosphate. This process is called phosphorolysis.
- ② This process continues until few glucose residues remain on either side of branching. The glycogen so formed is called limit dextrin.

### ② Action of debranching enzyme

- ① The branches of glycogen are cleaved by debranching enzyme.
- ② Amylo  $\alpha$ -1,6 glucosidase breaks  $\alpha$ -1,6 glucosidase bond & releases free glucose.

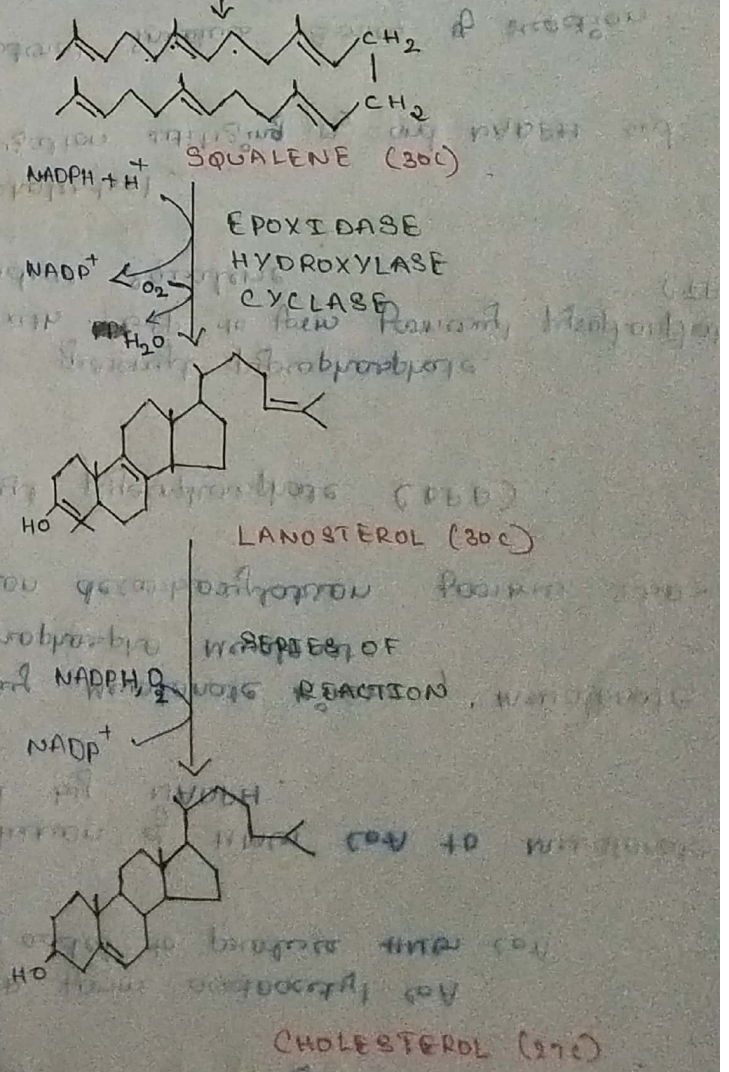
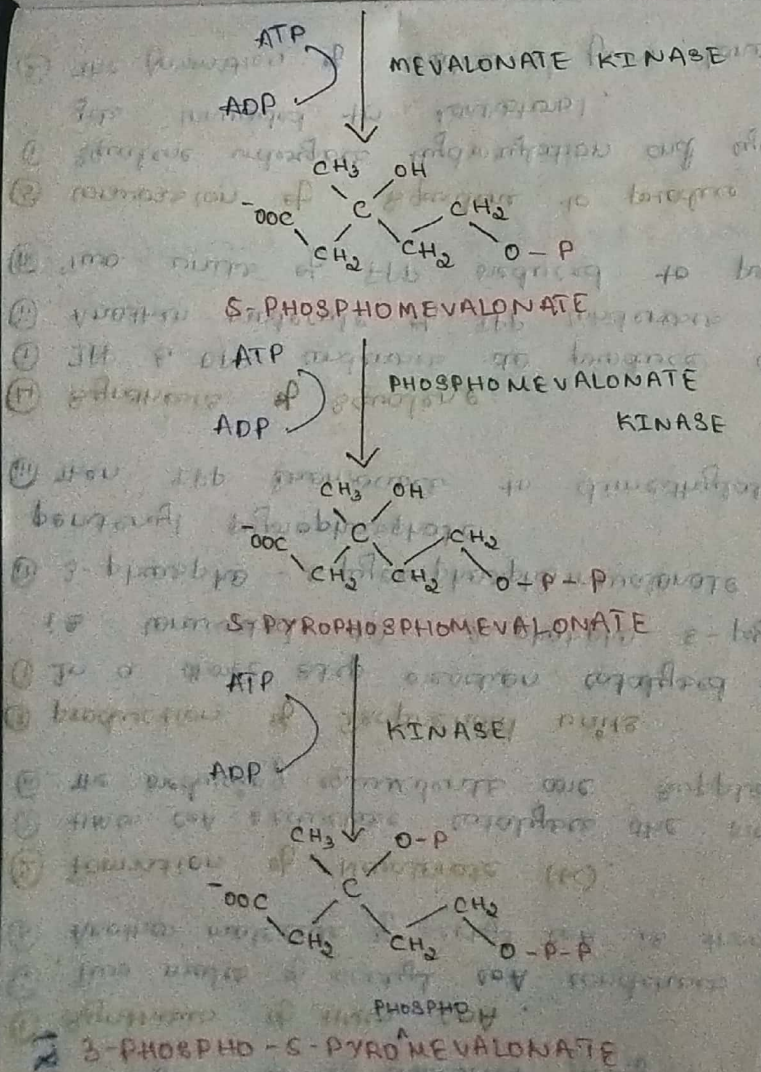
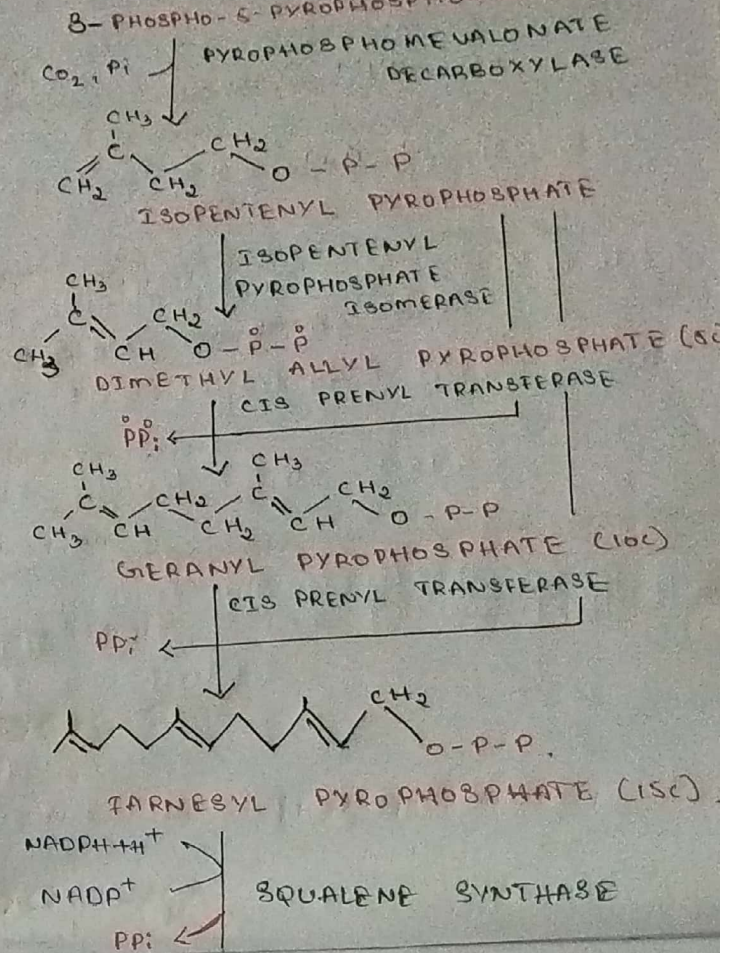
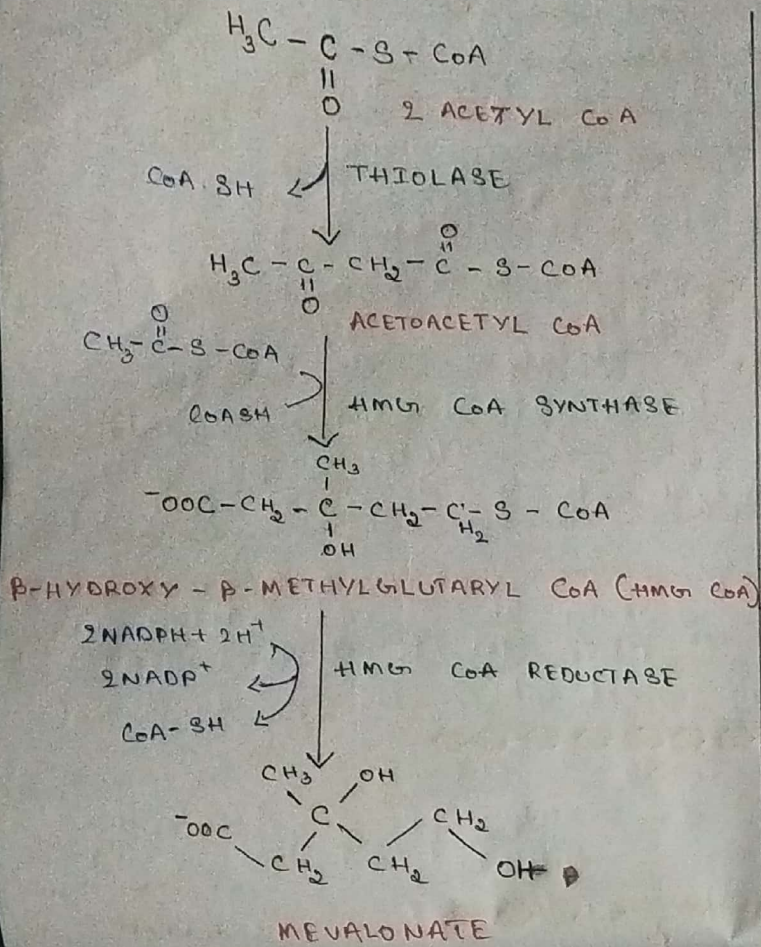
### ③ Formation of glucose-6-phosphate & glucose

- ① phosphoglucomutase converts glucose-1-phosphate to glucose-6-phosphate.
- ② glucose-6-phosphate is used in glycolysis to yield glucose.

Site: cytosol



Describe biosynthesis of cholesterol. Add a note on role of cholesterol in body.





The Synthesis of cholesterol may be learnt in 5 stages.

① Synthesis of HMG CoA.

① Two moles of acetyl CoA condense to form acetoacetyl CoA.

② Another molecule of acetyl CoA is then added to produce HMG CoA.

② Formation of Mevalonate (6C).

① HMG CoA reductase catalyses the reduction of HMG CoA to mevalonate.

② The reducing equivalents are supplied by NADPH.

③ production of Isoprenoid units

① In a three step reaction catalysed by mevalonate kinase, mevalonate is converted to 3-phospho 5-pyrophospho mevalonate.

② 3-phospho - 5-pyrophospho mevalonate on decarboxylation forms Isopentenyl pyrophosphate.

③ Then IPP isomerises to dimethylallyl pyrophosphate (DPP).

④ Synthesis of Squalene

① IPP & DPP condense to produce a geranyl pyrophosphate.

② Another molecule of IPP condenses with GPP to form farnesyl pyrophosphate (FPP).

③ Two units of FPP reduced to produce Squalene.

⑤ conversion of Squalene to produce cholesterol.

① Squalene undergoes hydroxylation and cyclization utilising  $O_2$  and NADPH and gets converted to lanosterol.

② The formation of cholesterol from lanosterol involves series of reaction.

Site :- Cyto Sol

Role of cholesterol in the body.

① It is a structural component of cell membrane.

② Cholesterol is the precursor for the synthesis of all steroids in the body.

③ It is an essential ingredient in the str of lipoprotein.

④ Fatty acids are transported to liver as cholesterol esters.



5 mark important concepts



① what are Isoenzymes? describe their diagnostic applications.

Ans: The multiple forms of an enzyme catalysing the same reactions are called Isoenzymes.

Diagnostic Importance of LDH (Lactate Dehydrogenase)  
Isoenzymes of LDH have immense value in the diagnosis of heart and liver related disorders.

In healthy individual, the activity of  $LDH_2$  is higher than that of  $LDH_1$  in serum. In the case of myocardial infarction,  $LDH_1$  is much greater than  $LDH_2$  and this happens within 12 to 24 hours after infarction.

Increased activity of  $LDH_5$  in serum is an indicator of liver diseases. LDH activity in the RBC is 80-100 times more than that in the serum. Hence for estimation of LDH, serum should be totally free from hemolysis.

② DI of creatine phosphokinase.

In healthy individual,  $CPK_2$  is almost undetectable in serum. After the MI  $CPK_2$  increases in the serum within first 6-18 hours. Estimation of the enzyme  $CPK_2$  is the earliest reliable indication of MI.

③ DI of Alkaline phosphatase

Six Isoenzymes of Alkaline phosphatase have been identified. The most important ALP isoenzymes are  $\alpha_1$ -ALP,  $\alpha_2$ -heat labile ALP,  $\alpha_2$ -heat stable ALP, pre- $\beta$  ALP,  $\mu$ -ALP, etc.

Increase in  $\alpha_2$ -heat labile ALP suggests hepatitis whereas pre  $\beta$ -ALP indicates bone diseases.



④  $\alpha$  &  $\beta$  of alcohol dehydrogenase  
Alcohol dehydrogenase (ADH) has two iso enzymes.  
Among the white American & European,  $\alpha$  &  $\beta$  isoenzyme is predominant, whereas in Japanese and Chinese  $\alpha$  &  $\beta_2$  is mostly present.  $\alpha$  &  $\beta_2$  more rapidly converts alcohol to acetaldehyde.

Accumulation of acetaldehyde is associated with tachycardia (increase in heart rate) and facial flushing among Japanese and Chinese which is not commonly seen in whites. It is believed that Japanese and Chinese have increased sensitivity to alcohol due to the presence of  $\alpha$  &  $\beta_2$  isoenzyme.

② Diagnosis of glucose tolerance test with its significance

① GTT is a test useful to diagnose the disease diabetes on the basis of individual response to oral glucose load.

② The person should take carbohydrate-rich diet for at least 3-days prior to the test.

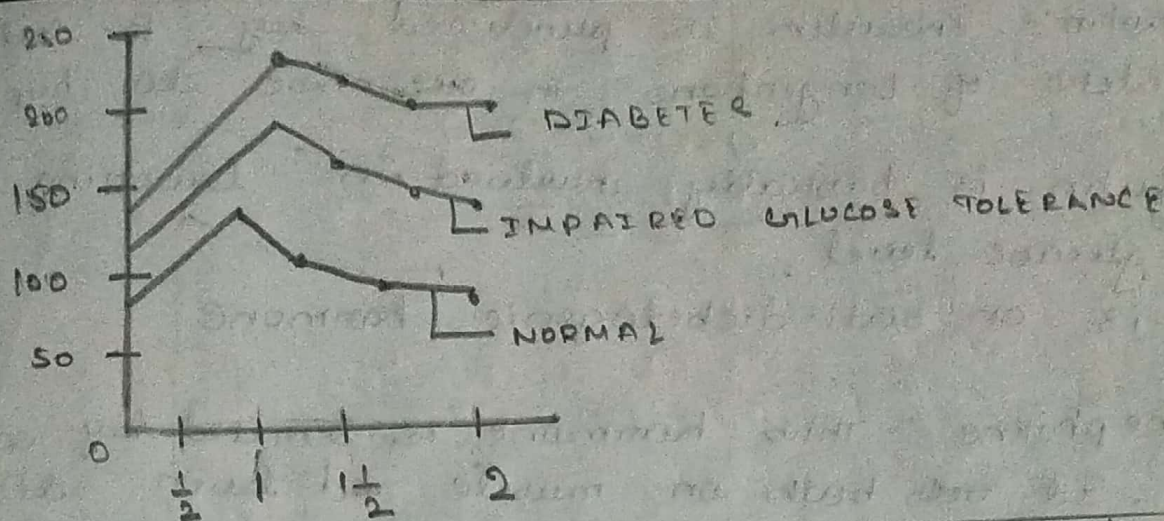
③ The person should be in fasting 1 night before test. It is conducted preferably in the morning.

④ In a normal individual, fasting plasma glucose 70-110 mg/dl, on oral glucose load the concentration increases and peak value is reached, which returns to normal within 2 hours.

⑤ Fasting <sup>plasma</sup> glucose should be below 110 mg/dl above 126 mg/dl is diagnostic of diabetes.

⑥ Individual with impaired glucose tolerance the fasting & 2 hours glucose plasma levels are elevated. This slowly develops into diabetes at an estimated rate of 2% every year.





| Condition             | Normal | Impaired glucose tolerance | Diabetes |
|-----------------------|--------|----------------------------|----------|
| Fasting               | <110   | <126                       | >126     |
| 2 hours after glucose | <140   | <200                       | >200     |

### Significance

- ① To determine how quickly glucose is cleared from blood.
- ② It assist diagnosis of diabetes
- ③ used in evaluation of patients with hypoglycemia
- ④ Explain hormonal regulation of blood glucose level in the body.
- ⑤ Glucagon: Glucagon is synthesized by  $\alpha$ -cells of islets of Langerhans of pancreas. Hypoglycemia stimulates its production. Glucagon is basically involved in elevating blood glucose level concentration. It enhances gluconeogenesis and glycogenolysis.



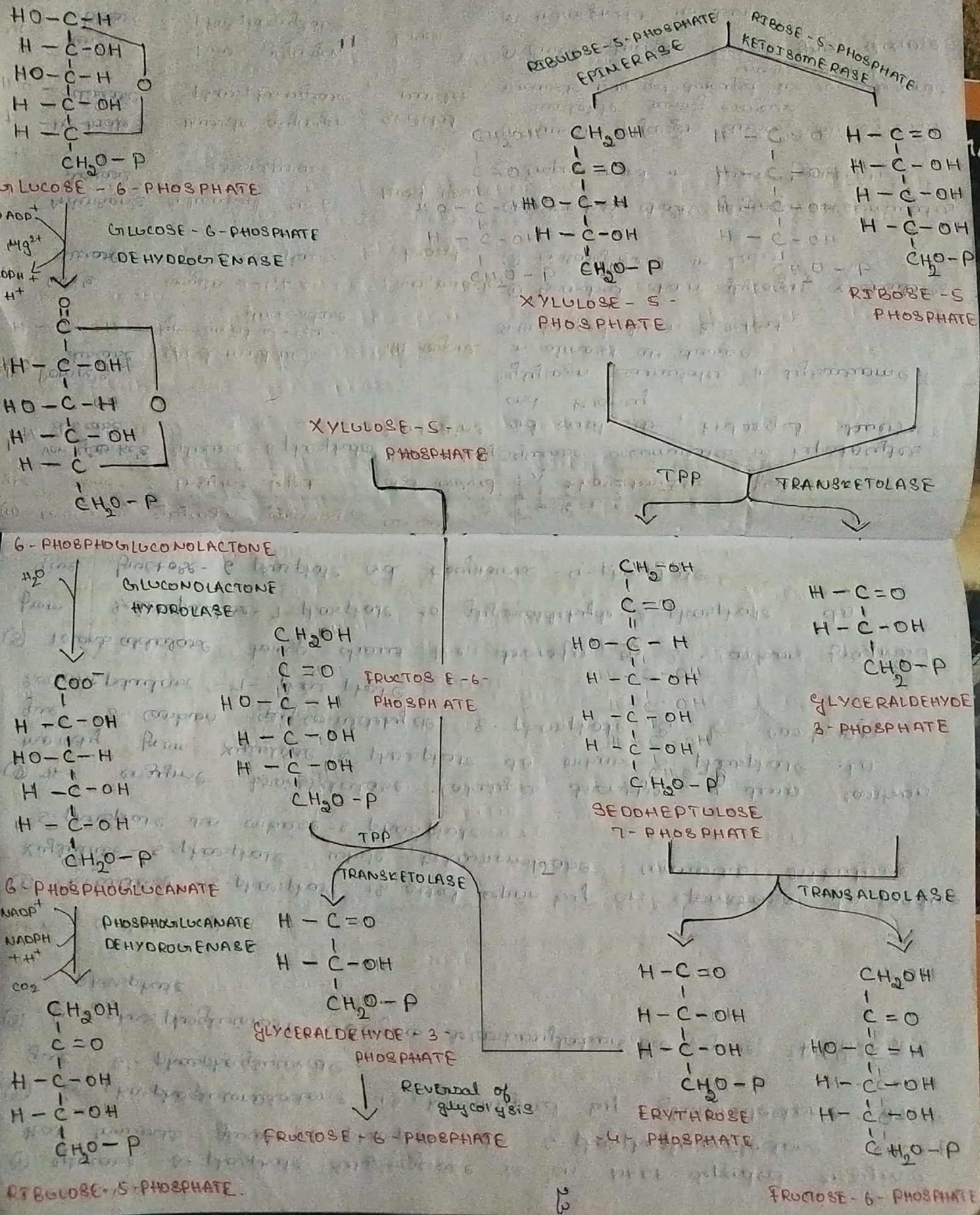
- ①. Insulin: Insulin is produced by  $\beta$ -cells of islets of Langerhans in response to hyperglycaemia.
- ②. Insulin is basically involved in lowering of blood glucose level.
- ③ It is an anti-diabetogenic hormone.
- ③ Epinephrine: This hormone is secreted by adrenal gland. It acts both on muscle and liver to bring about glycogenolysis. The
- ② The end product is glucose in liver and lactate in muscle.
- ③ The Epinephrine increases blood glucose level.
- ④ Thyroxine
- ① It is a hormone of thyroid gland. It elevates blood glucose level by stimulating hepatic glycogenolysis & gluconeogenesis.
- ⑤ Glucocorticoids
- ① This hormone is secreted by adrenal glands.
- ② Glucocorticoids stimulates protein metabolism and increases gluconeogenesis.
- ③ It elevates blood glucose concentration.
- ⑥ Growth hormone & ACTH
- ① It is secreted by pituitary gland.
- ② It decreases uptake of glucose by certain tissues.
- ③ It increases blood glucose level.



| Glycogen storage diseases |                      |                                                       |                           |                                                                                                                               |
|---------------------------|----------------------|-------------------------------------------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| Type                      | Name                 | Enzyme defect                                         | Organ involved            | Characteristic features                                                                                                       |
| I                         | Von Gierke's disease | Glucose-6-phosphatase                                 | Liver, Kidney & Intestine | ① Glucose accumulates in hepatocytes and renal cells, Enlarged liver and kidney                                               |
| II                        | Pompe's disease      | (Acid maltase)<br>Lysosomal $\alpha$ -1,4-glucosidase | All organs                | ① Glycogen accumulates in lysosome in almost all tissue<br>② Enlarged liver & heart                                           |
| III                       | Corn's disease       | Branch $\alpha$ -1,6-glucosidase                      | Liver, muscle heart.      | ① Branched chain glycogen accumulates<br>② Enlargement in liver                                                               |
| IV                        | Anderson's disease   | Glucosyl 4-6 transferase                              | Heart tissue              | ① Branched chain glycogen accumulates<br>② Impairment in liver function                                                       |
| V                         | Mc Ardle's disease   | Muscle glycogen phosphorylase                         | Skeletal muscles          | ① Muscle glycogen stores very high, not available during exercise<br>② muscle may get damaged due to inadequate energy supply |
| VI                        | Hen's disease        | Liver glycogen phosphorylase                          | Liver                     | ① Liver glycogen cannot form glucose<br>② Enlargement in liver                                                                |
| VII                       | Tarui's disease      | Phosphofructo-kinase                                  | Skeletal Muscles.         | Muscle cramps due to exercise                                                                                                 |



⑤ outline various biochemical reaction involved in HMP shunt pathway and write its significance  
 Ans. HMP is an alternate pathway to glycolysis and TCA cycle for the oxidation of glucose





### ① oxidative phase

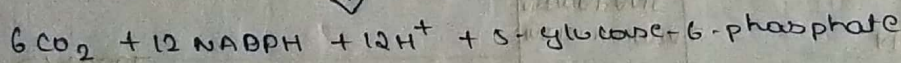
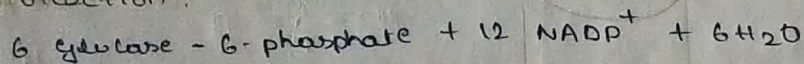
- ① glucose-6-phosphate dehydrogenase is an NADP dependent enzyme that converts glucose-6-phosphate to 6-phosphogluconolactone
- ② 6-phosphogluconolactone is hydrolysed by gluconolactonase to give 6-phosphogluconate
- ③ 6-phosphogluconate undergoes decarboxylation to give Ribulose-5-phosphate

### Non-oxidative phase

- ① Ribulose-5-phosphate is acted upon by an epimerase to produce Xylulose-5-phosphate while ketotransmerase converts ribulose-5-phosphate to ribose-5-phosphate
- ② The enzyme transketolase catalyses transfer of two carbon moiety from xylulose-5-phosphate to ribose-5-phosphate to give 3-carbon glyceraldehyde 3-phosphate & 7-carbon sedoheptulose-7-phosphate
- ③ Transaldolase brings about the transfer of 3-carbon fragment from sedoheptulose-7-phosphate to glyceraldehyde-3-phosphate to give fructose-6-phosphate and Erythrose-4-phosphate

④ Transketolase acts on xylulose-5-phosphate and transfers 2-carbon fragment from it to erythrose-4-phosphate to generate fructose-6-phosphate and glyceraldehyde-3-phosphate

⑤ Fructose-6-phosphate and glyceraldehyde-3-phosphate can be further catabolized through glycolysis and citric acid cycle. Glucose may also be synthesized from these two compounds overase reaction.

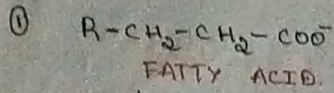


### Significance

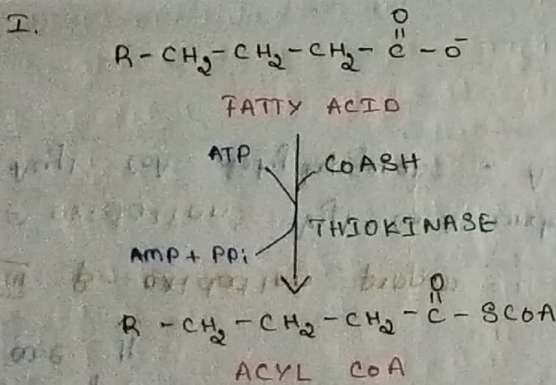
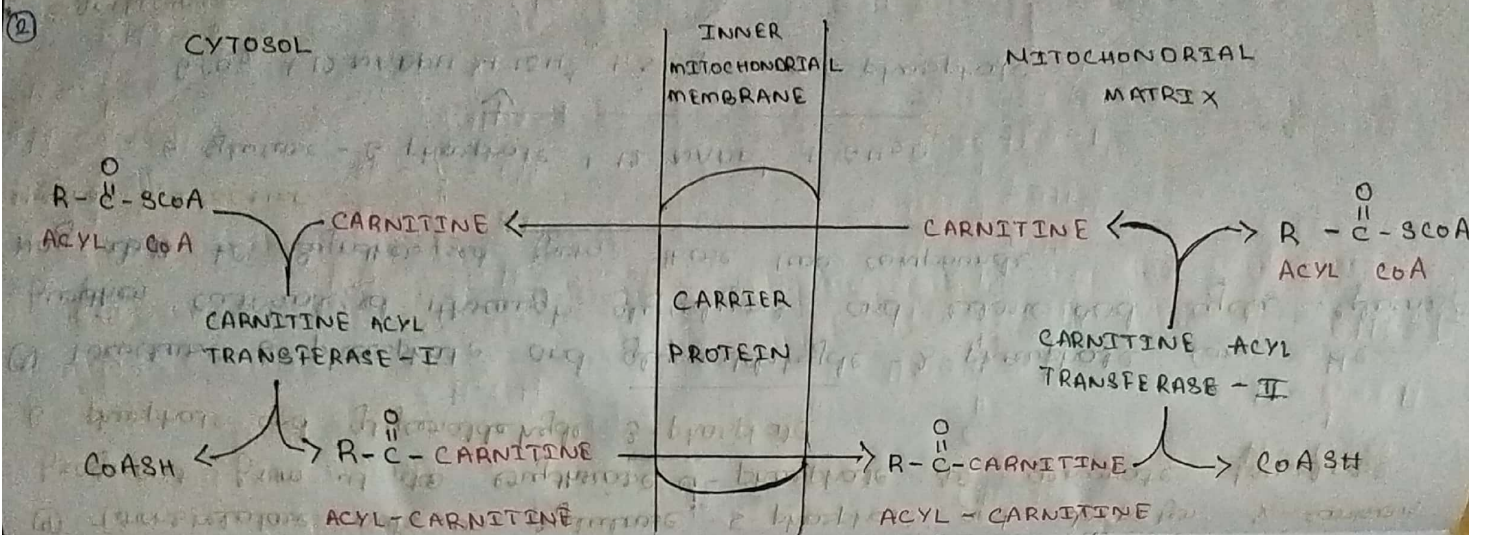
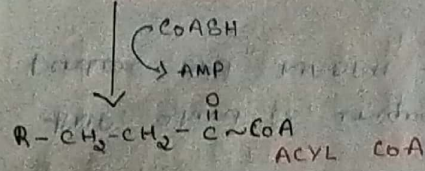
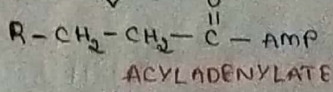
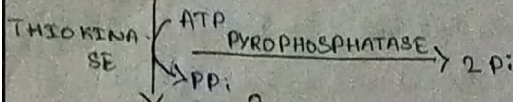
HMP shunt is unique in generating two important products - Pentate and NADPH - needed for biosynthetic reaction & other functions



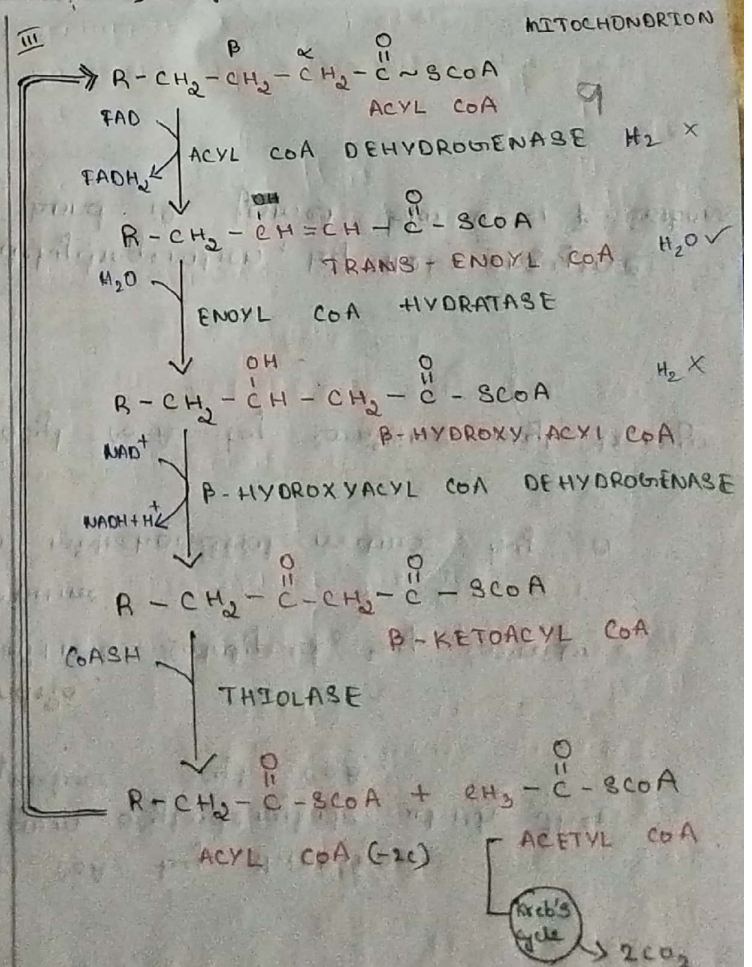
⑥  $\beta$ -oxidation of fatty acids, calculate ATP generation on oxidation of ~~Palmitic~~ palmitic acids



8



II CARNITINE TRANSPORT SYSTEM





$\beta$ -oxidation of Fatty Acid  
oxidation of fatty acids on the  $\beta$ -carbon atom, which results in sequential removal of two carbon fragment.

### I. Fatty Acid Activation.

- ① Fatty Acids are activated to Acyl CoA by thiokinase
- ② Fatty Acid react with ATP to form acyladenylate which then combines with Co-enzyme A to produce acyl CoA.

### II Transport of acyl CoA into mitochondria.

- ① acyl CoA is transformed into carnitine catalysed by carnitine acyltransferase I, to yield acyl carnitine.
- ② acyl carnitine is transported into mitochondrial matrix by a specific carrier protein.
- ③ Acyl-carnitine is converted to acyl Co-A by carnitine acyl transferase II.

### III $\beta$ -oxidation proper

- ① oxidation: Acyl Co-A undergoes dehydrogenation, by the enzyme Acyl CoA dehydrogenase. A double bond is formed b/w  $\alpha$  &  $\beta$  carbons.

- ② hydration: Enoyl CoA hydratase brings about the hydration of the double bond to form  $\beta$ -hydroxy Acyl CoA.

- ③ oxidation:  $\beta$ -Hydroxy Acyl CoA Dehydrogenase catalyses the second oxidation and generates  $\beta$ -ketoacyl Co-A.

- ④ Cleavage: In the final step two carbon fragment, acyl CoA & Acetyl CoA gets liberated, which is catalysed by Thiolase.

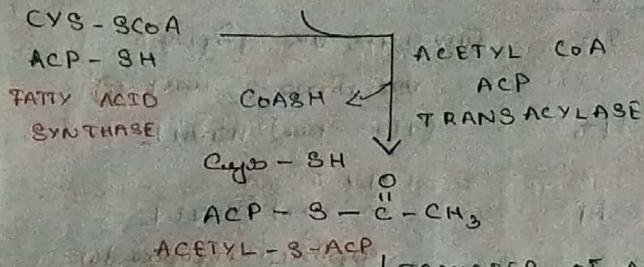
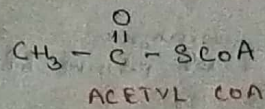
Site: Mitochondria

### Energetics of palmitic acid

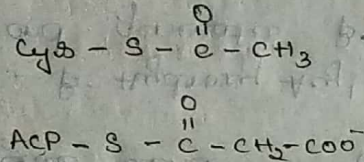
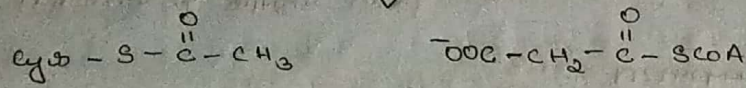
| Mechanism                            | ATP yield |
|--------------------------------------|-----------|
| ① $\beta$ -oxidation 7 cycles        |           |
| 7 $\text{FADH}_2$ (each gives 2 ATP) | 14        |
| 7 NADH (each 3 ATP)                  | 21        |
| ② From 8 acetyl CoA                  |           |
| 8 acetyl CoA (each 12 ATP)           | 96        |
|                                      | <hr/> 131 |
| Energy utilized for activation       | -2        |
|                                      | <hr/> 129 |



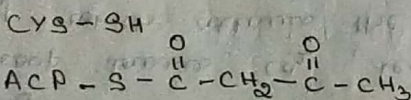
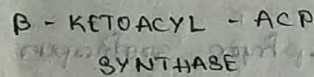
# ① Biosynthesis of Fatty Acids



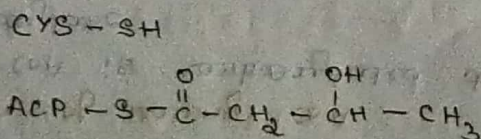
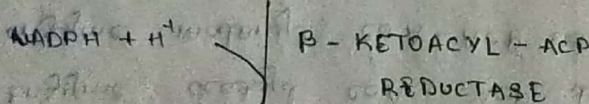
TRANSFER OF ACETYL TO CYSTEINE



ACYL MALONYL ENZYME

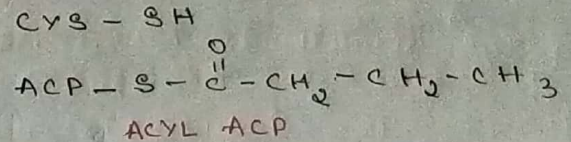
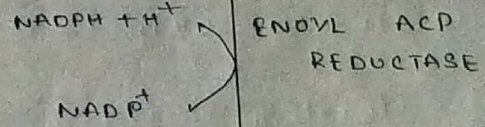
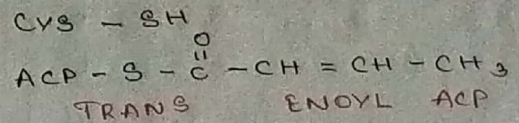
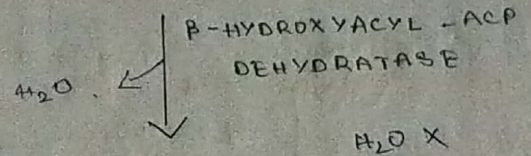


β-KETOACYL-ACP

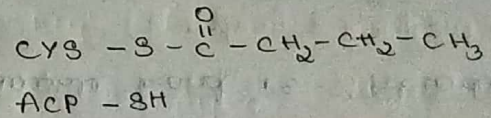


β-HYDROXYACYL-ACP

β-HYDROXYACYL-ACP

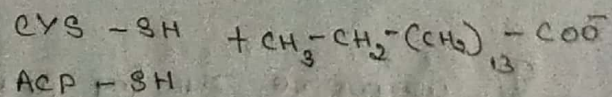
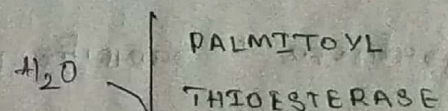
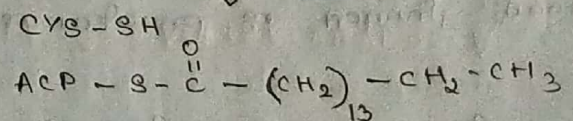


TRANSFER OF CARBON CHAIN FROM ACP TO CYS



ACYL-S-ENZYME

REACTIONS 2-6  
REPEATED SIX  
MORE TIMES



PALMITATE



The fatty acid Synthesis may be learnt in 3 stages

① production of acetyl coA & NADPH

① Acetyl coA is produced in the mitochondria by the oxidation of pyruvate & fatty acids

② Formation of Malonyl coA

① Acetyl coA is carboxylated to malonyl coA by the enzyme acetyl CoA carboxylase.

③ Reaction of fatty acid Synthase complex

① Acetyl coA is transferred to ACP of Fatty Acid Synthase, catalysed by the enzyme acetyl coA - ACP transacylase

② The enzyme Malonyl coA - ACP transacylase transfers malonate from malonyl coA to bind ACP.

③ The acetyl unit attached to cysteine is transferred to malonyl group. malonyl group loses  $\text{CO}_2$ , decarboxylation is accompanied by loss of free energy which allows the reaction to proceed forward. The reaction is catalysed by  $\beta$ -ketoacyl ACP Synthase.

④  $\beta$ -ketoacyl ACP reductase reduces  $\beta$ -ketoacyl ACP to  $\beta$ -hydroxy ACP. The reducing equivalents are supplied by NADPH.

⑤  $\beta$ -hydroxyacyl ACP undergoes dehydration, double bond is introduced b/w  $\alpha$  &  $\beta$  carbon.

⑥ TransEnoyl ACP is reduced to Acyl ACP by the enzyme Enoyl ACP Reductase

- Reaction 2-6 repeated 6 more times

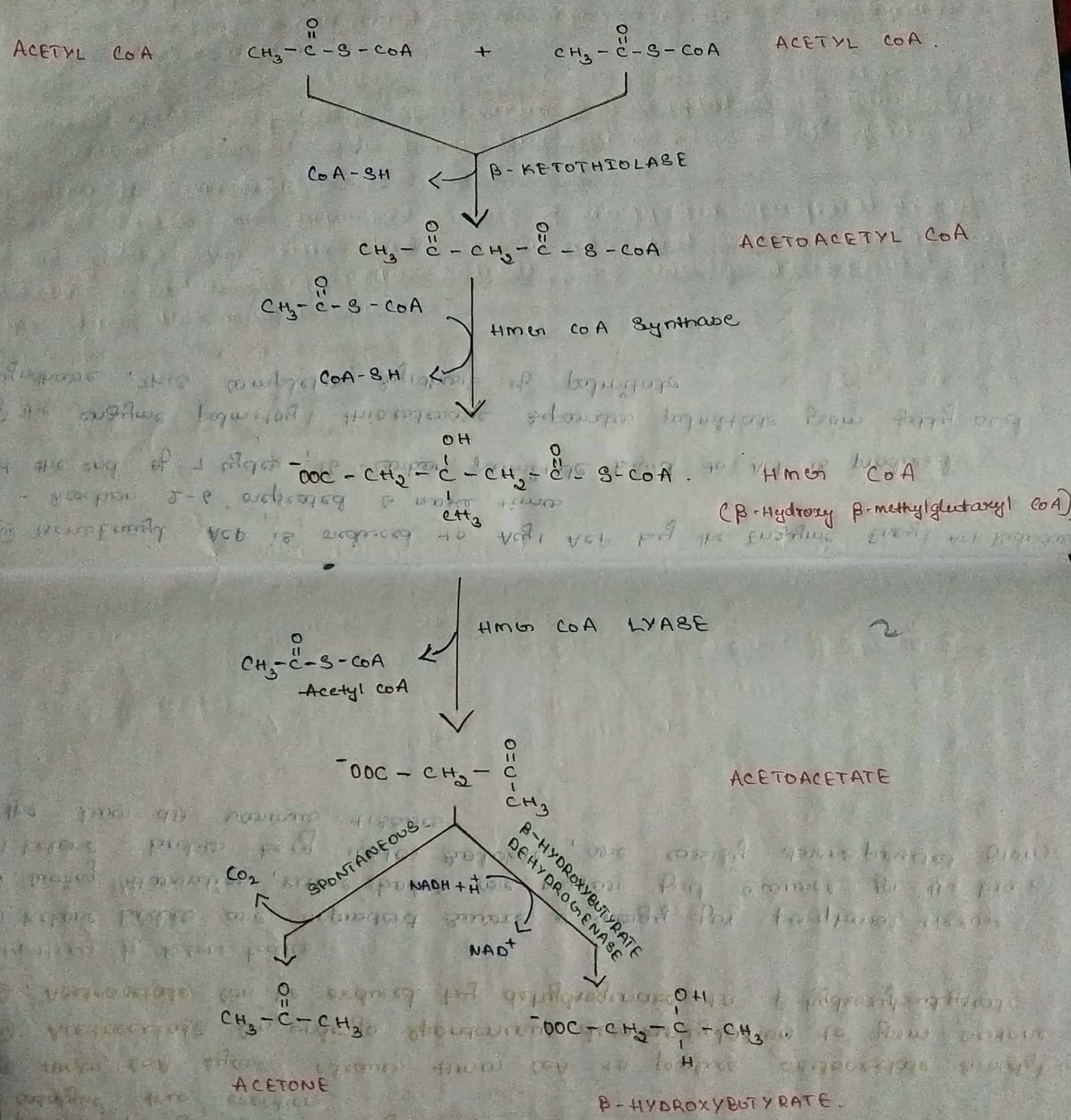
At the end of 7 cycles, 16-carbon palmitate bound to ACP is produced

⑦ The enzyme palmitoyl thioesterase separates palmitate from fatty acid synthase. This completes synthesis of palmitate.



Q. What are ketone bodies? Explain the formation & importance of ketone bodies.

Ans. Ketone bodies are water soluble & energy yielding compounds. Compounds namely acetone, acetoacetate and  $\beta$ -hydroxybutyrate are known as ketone bodies.





## Ketogenesis

The Synthesis of ketone bodies is called ketogenesis

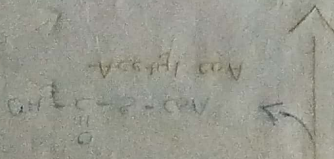
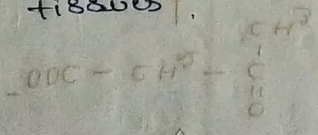
3

Ketogenesis occurs through following reactions

- ① Two moles of acetyl CoA condense to form acetoacetyl CoA. This reaction is catalysed by Thiolase.
- ② Acetoacetyl CoA combines with another molecule of acetyl CoA to produce  $\beta$ -Hydroxy  $\beta$ -methylglutaryl CoA (HMG CoA). HMG CoA Synthase catalyse this reaction.
- ③ HMG CoA lyase cleaves HMG CoA to produce acetoacetate & acetyl CoA.
- ④ Acetoacetate can undergo spontaneous decarboxylation to form acetone.
- ⑤ Acetoacetate can be reduced by dehydrogenase to  $\beta$ -hydroxybutyrate.

## Importance of ketone bodies

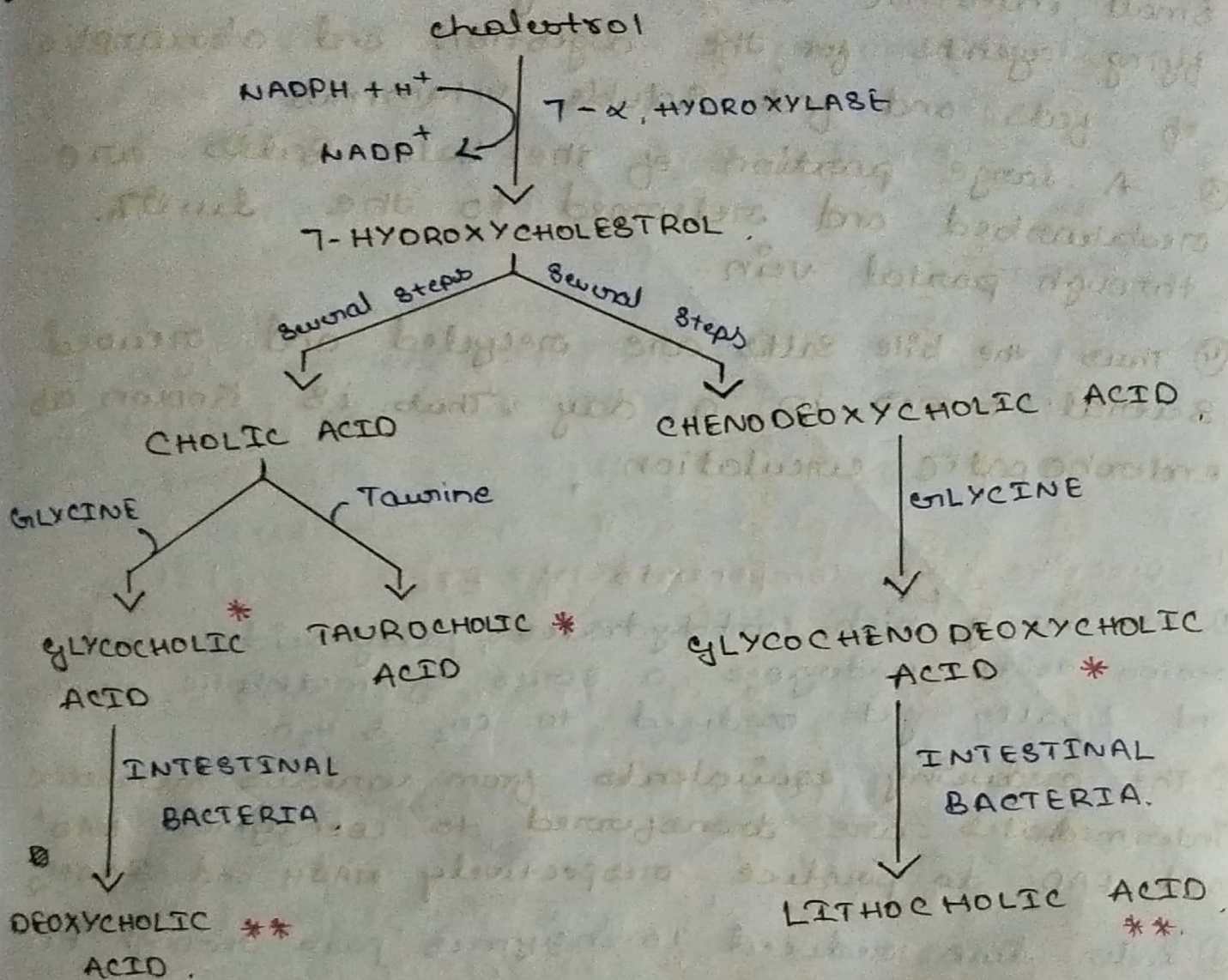
- ① Ketone bodies are important source of energy for peripheral tissue.
- ② During starvation, ketone bodies are major fuel source for the brain.
- ③ Ketone bodies being water-soluble, are easily transported from the liver to various tissues.





Q Describe briefly the Synthesis of bile acids ?  
Add a note on enterohepatic circulation of bile salts

Ans: Synthesis of bile acids



- ① The Synthesis of primary bile acids takes place in the liver and involves a series of reaction.
- ② Cholic acid and chenodeoxycholic acids are the primary bile acids
- ③ on conjugation with glycine & taurine, glycocholic acid, Taurocholic acid & glychenodeoxycholic acids are formed.
- ④ In the Intestine, a portion of primary bile acids undergoes deconjugation & decarboxylation to form Secondary bile acids.

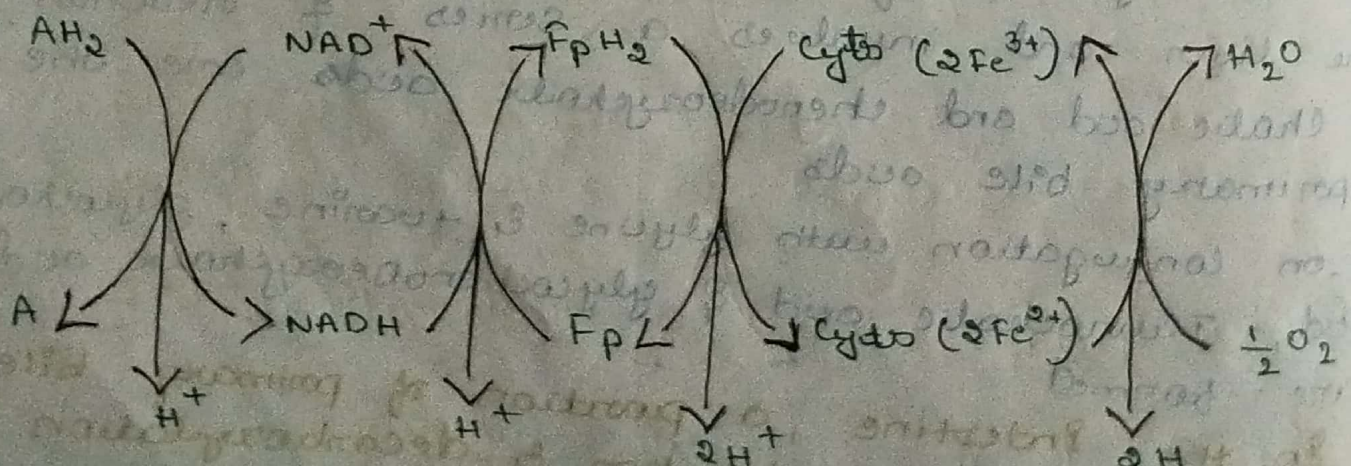


## Entero hepatic circulation

- ① The conjugated bile salts synthesized in the liver accumulate in gall bladder
- ② From there they are secreted into the small intestine where they serve as emulsifying agents for the digestion and absorption of fats and fat soluble vitamins
- ③ A large portion of the bile salts are reabsorbed and returned to the liver through portal vein.
- ④ Thus the bile salts are recycled and reused several times in a day. This is known as enterohepatic circulation.

## 10 Describe the components of ETC

- ① The energy rich carbohydrates, fatty acids and amino acids undergo a series of metabolic reaction and finally get oxidized to  $\text{CO}_2$  &  $\text{H}_2\text{O}$
- ② The reducing equivalents from various metabolic intermediates are transformed to coenzymes  $\text{NAD}^+$  and  $\text{FAD}$  to produce respectively  $\text{NADH}$  and  $\text{FADH}_2$
- ③ Later these reduced co-enzymes pass through ETC and finally reduces oxygen to water



(A - Substrate, Fp - Flavinoprotein, Cyto - Cytochrome)

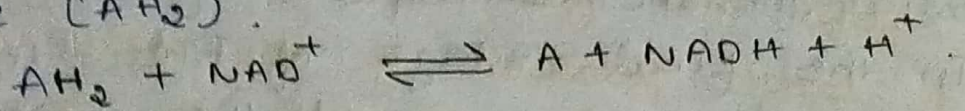


## Components of ETC

### ① Nicotinamide nucleotides

① of the two co-enzyme  $\text{NAD}^+$  and  $\text{NADP}^+$  derived from the vitamin niacin,  $\text{NAD}^+$  is more actively involved in the ETC.

②  $\text{NAD}^+$  is reduced to  $\text{NADH} + \text{H}^+$  by dehydrogenase with the removal of two hydrogen atoms from the substrate ( $\text{AH}_2$ ).



### ② Flavoproteins

① The enzyme NADH dehydrogenase is a flavoprotein with FMN as the prosthetic group. The co-enzyme FMN accepts two electrons and a proton to form  $\text{FMNH}_2$ .



### ③ Iron - Sulphur proteins

① Iron-Sulphur ( $\text{FeS}$ ) proteins exist in the oxidized ( $\text{Fe}^{3+}$ ) or reduced ( $\text{Fe}^{2+}$ ) state.

② About half a dozen  $\text{FeS}$  protein connected with respiratory chain have been identified.

③ The mechanism of action of  $\text{FeS}$  proteins in the ETC is not clearly understood.

### ④ Co-enzyme Q

① Co-enzyme Q is also known as ubiquinone.

② It is a quinone derivative with a variable isoprenoid side chain.

③ Co-enzyme Q is a lipophilic electron carrier. It can accept electrons from  $\text{FMNH}_2$  produced in the ETC by NADH dehydrogenase.



### ⑤ cytochromes

① The cytochromes are conjugated proteins containing heme group

② It consists of porphyrin ring with iron atom

③ The Iron of heme group in cytochromes is alternatively oxidized and reduced, which is essential for the transport of electrons in the ETC.

④ In the final stage of ETC, the transported  $e^-$ , the free protons and the molecular oxygen combines to produce water.

⑪ what is oxidative phosphorylation? How does it differ from substrate level phosphorylation?

Ans: The process of synthesizing ATP from the ADP and  $P_i$  coupled with the electron transport chain is known as oxidative phosphorylation

Site: The complex V of inner mitochondrial membrane

#### Substrate level phosphorylation

① It is a type of phosphorylation in which phosphate group is transferred from a substrate to ADP

② occurs in the cytoplasm and mitochondrial matrix

③ Direct phosphorylation

④ occurs in glycolysis and Krebs cycle

#### oxidative phosphorylation

① It is a type of phosphorylation which uses the energy released from the electron transport chain to generate ATP

② occurs in inner mitochondrial membrane

③ Indirect phosphorylation

④ occurs in the electron transport chain



⑤ Fewer ATPs are produced

⑥ NAD and FAD are reduced

⑦ The change of the redox potential of the substrate is less

⑧ partial oxidation of the substrate

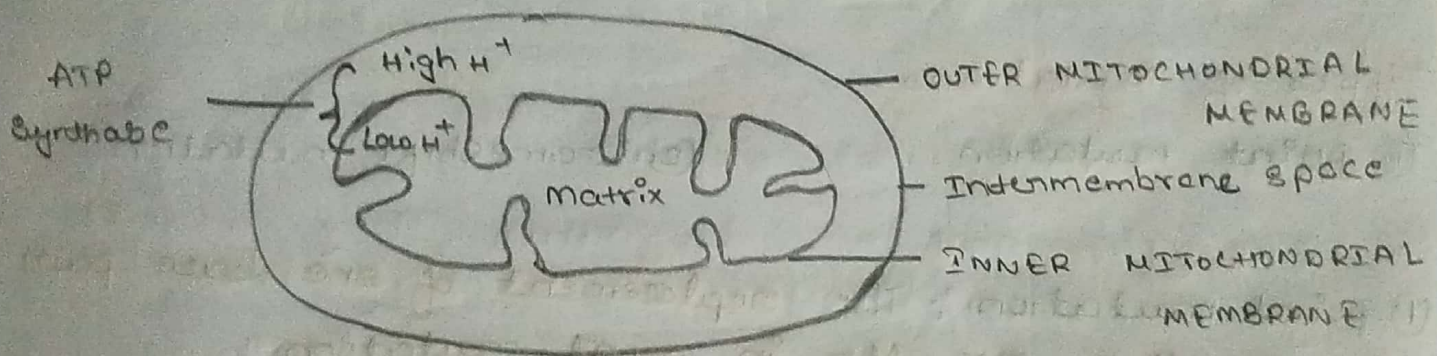
⑤ thirty four ATPs are produced

⑥  $\text{NADH}^+$  and  $\text{FADH}^+$  are oxidized

⑦ The change of the redox potential of the substrate is more

⑧ complete oxidation of the  $\text{e}^-$  donors

⑫ Explain the chemiosmotic theory of oxidative phosphorylation?



⑪ This mechanism was proposed by Peter Mitchell. It explains how electron transport in ETC is effectively utilized to produce ATP from ADP +  $\text{P}_i$ .

⑫ Proton gradient:

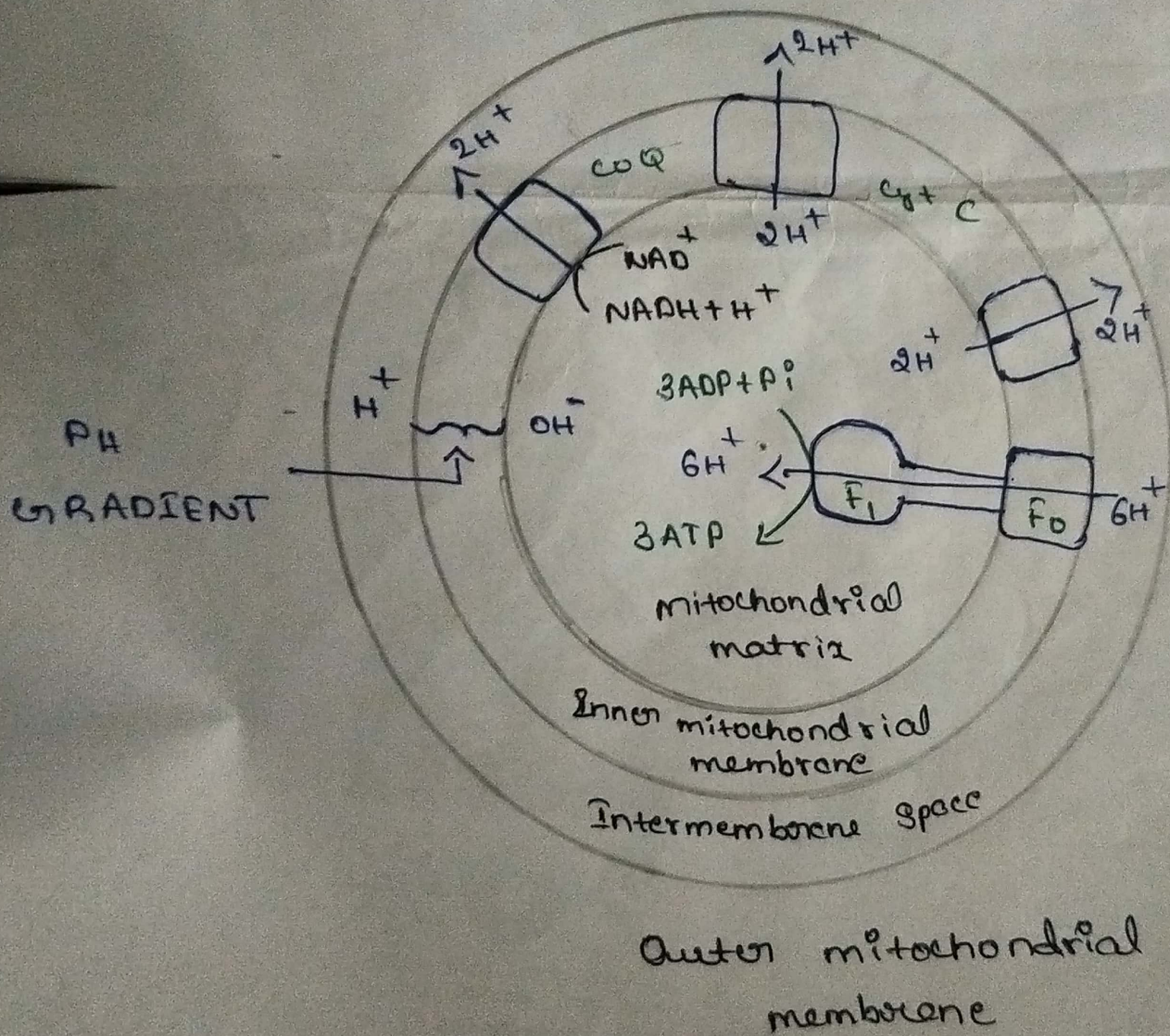
- ① The inner mitochondrial membrane is impermeable to  $\text{H}^+$  &  $\text{OH}^-$ .
- ② The transport of electron through ETC is coupled with proton across inner mitochondrial membrane.
- ③ The pumping of proton results in proton gradient.
- ④ This is due to accumulation of more  $\text{H}^+$  ions on the outer side than the inner side of inner mitochondrial membrane.
- ⑤ The proton gradient developed is sufficient to synthesize ATP from ADP and  $\text{P}_i$ .



### ③ Enzyme System for ATP Synthesis

- ① ATP Synthase utilizes the proton gradient for the synthesis of ATP.
- ② ATP Synthase is a complex enzyme and consists of two functional subunits, namely  $F_1$  and  $F_0$ .
- ③ Its structure is comparable with 'ballpops'.
- ④ The protons that accumulate in the intermembrane space re-enter the mitochondrial matrix leading to the synthesis of ATP.







Q3 Define mutation, Explain various types of the same

Ans:- The undesirable change in DNA structure of a gene is known as mutation

Types of mutations

① point mutation

② Frameshift mutation

① point mutation:- The replacement of one base pair by another results in point mutation

(i) Transitions:- Here purine is replaced by another purine

(ii) Transversions:- Here purine is replaced by pyrimidine or vice versa

② Frameshift mutation:- These occur when one or more base pairs are inserted or deleted from the DNA



## ① Consequences of point mutation

- ① Silent mutation: Here, the changed base code for same amino acid.
- ② missense mutation: Here, the changed base code for different amino acid.
- ③ Nonsense mutation: Here, the changed base become a termination codon.

## ② Consequence of frameshift + mutation

- ① The m-RNA does not recognise the base that was missing or newly added.
- ② protein synthesized from translation will have several altered amino acids.

## 14) Describe different DNA repair mechanisms

### ① Base excision repair.

- ① A defective DNA in which cytosine is deaminated to uracil is acted upon enzyme uracil DNA glycosylase. results in removal of defective base uracil.

- ② An endonuclease cuts the backbone of DNA strand near the defect and removes few bases.

- ③ The gap so created is filled up by DNA ~~ligase~~ polymerase.

### ② Nucleotide excision repair

- ① The mechanism is ideally suited for large scale defects in DNA.



② After the Identification of the defective piece of DNA, the DNA double helix is unwound to expose the damaged part

③ An endonuclease cuts the DNA on either side of the damaged DNA. This defective piece is degraded

④ The gap so created is filled up by DNA polymerase

⑤ Mismatch repair

① Despite high accuracy in replication, defects do occur when the DNA is copied

② For ex: Cytosine could be incorporated in opposite to adenine instead of guanine

③ Mismatch repair corrects single mismatch base pairs

④ Double - strand break repair

① DSB's in DNA are dangerous. They result in genetic recombination which may lead to broken chromosomes, and finally cell death

② DSB's can be repaired by homologous recombination

⑤ Define genetic code and describe characteristic features.

Ans:- The triplet base sequence in m-RNA that act as code words for amino acids is known as genetic code



- ① The code is a triplet codon
- ① The nucleotides of m-RNA are arranged as a linear sequence
- ② Each codon consists of three successive nitrogenous bases
- ② The code is non-overlapping <sup>but</sup>
  - ① code do not overlap read sequentially
  - ② six bases code for not more than two amino acids.
- ③ The code is commaleas
  - ① The genetic code is commaleas, that means no codon is reserved for punctuations
  - ② after one amino acid is coded, the second amino acid will be coded by the next three letters automatically
- ④ The code is non-ambiguous
  - ① A particular codon will always code for the same amino acid
- ⑤ The code is universal
  - ① Some genetic code is found valid for all organisms ranging from bacteria to man.
  - ② same codons are used to code for some amino acids in all organisms
- ⑥ The code is degenerative
  - ① one amino acid may be coded by more than one codon.
  - ② This is called degeneracy of the code



⑦ Some codons act as start codons  
① In most organisms, AUG codon is the start codon

⑧ Some code acts as stop codon

① Three codons, UAG, UAA and UGA are the termination codon.

② They do not code for any of the amino acids

⑩ what is jaundice and explain the different types of jaundice

Ans: ① Jaundice is a clinical condition characterized by the yellow colour of the eye and skin

② It is caused by the deposition of bilirubin due to its elevated levels in the serum

① Hemolytic Jaundice

① This condition is associated with increased hemolysis of erythrocytes

② This results in the over-production of bilirubin beyond the ability of the liver to excrete

It is characterized by

(i) Elevation in serum bilirubin

(ii) Increased excretion of urobilinogen in urine

(iii) Dark brown colour of feces due to stercobilinogen

② Hepatic Jaundice

① This type of jaundice is caused by dysfunction of the liver due to damage to the parenchymal cells by viral infection, toxins or poisons

② Damage to the liver adversely affects the bilirubin uptake



It is characterized by

- ① Affected individuals experience nausea & ~~loss~~ anorexia
- ② above characters

### ③ obstructive jaundice

- ① This is due to an obstruction in the bile duct that prevents the passage of bile into the intestine
- ② obstruction is due to gall stones & tumors

It is characterized by

- ① patient experience nausea and gastrointestinal pain
- ② above characters ..

⑩ what is porphyria ? Explain the types.

Ans: ① porphyrias are the metabolic disorders of heme synthesis, characterized by the increased excretion of porphyrins

### ① Acute intermittent porphyria

- ① It is caused due to deficiency of the enzyme uroporphyrinogen III synthase

② It is usually expressed after puberty

③ Symptoms include abdominal pain, vomiting and cardiovascular abnormalities

### ② Congenital erythropoietic porphyria

- ① It is caused due to defect in the enzyme uroporphyrinogen III cosynthase

② The patients are photosensitive

③ Increased hemolysis is observed in the individuals affected by this disorder



### ③ porphyria cutanea tarda

- ① It is caused due to deficiency of the enzyme  $\delta$ -ALA dehydratase
- ② The patients are photosensitive
- ③ Increased excretion of  $\delta$ -ALA is observed

### ④ Hereditary coproporphyria

- ① It is caused due to deficiency of the enzyme coproporphyrinogen oxidase
- ② The patients are photosensitive
- ③ Symptoms include abdominal pain, vomiting, and cardiovascular abnormalities

### ⑤ Variegate porphyria

- ① It is caused due to defect in the enzyme  $\delta$ -ALA dehydratase
- ② The patients are photosensitive
- ③ urine of the patient is coloured

### ⑥ protoporphyria

- ① It is caused by deficiency of the enzyme ferrochelatase
- ② protoporphyrin accumulates in the tissue and excrete in urine

### ⑧ Explain phenylketonuria and alkaptonuria

#### ① phenylketonuria

- ① It is due to the deficiency of the hepatic enzyme phenylalanine hydroxylase
- ② Due to deficiency of phenylalanine hydroxylase there will be no breakdown of phenylalanine



③ phenylalanine may build up in the body and cause brain damage, this may lead to serious growth and learning problems, such as mental retardation

### Diagnosis of PKU

- ① Blood test :- A newborn screening test is usually done. A sample of child blood is taken and sent to the lab
- ② Guthrie test :- medical test performed on newborn babies to detect phenylketonuria

### Treatment

- ① Diet :- maintenance of plasma phenylalanine is done by selecting food with low phenylalanine content
- ② medicines :- medicines may be given to treat nausea, vomiting etc

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### ② Alkaptonuria

- ① It is due to defect in the enzyme Homogentisate oxidase (HMO)
- ② Symptoms includes Arthritis, Darkening of the ear, Dark spots on white eye
- ③ Homogentisate accumulates in tissue and blood and is excreted into urine

### Diagnosis

- ① A urine test is done to test for alkaptonuria
- ② change in colour of the urine on standing been the simple traditional method to identify

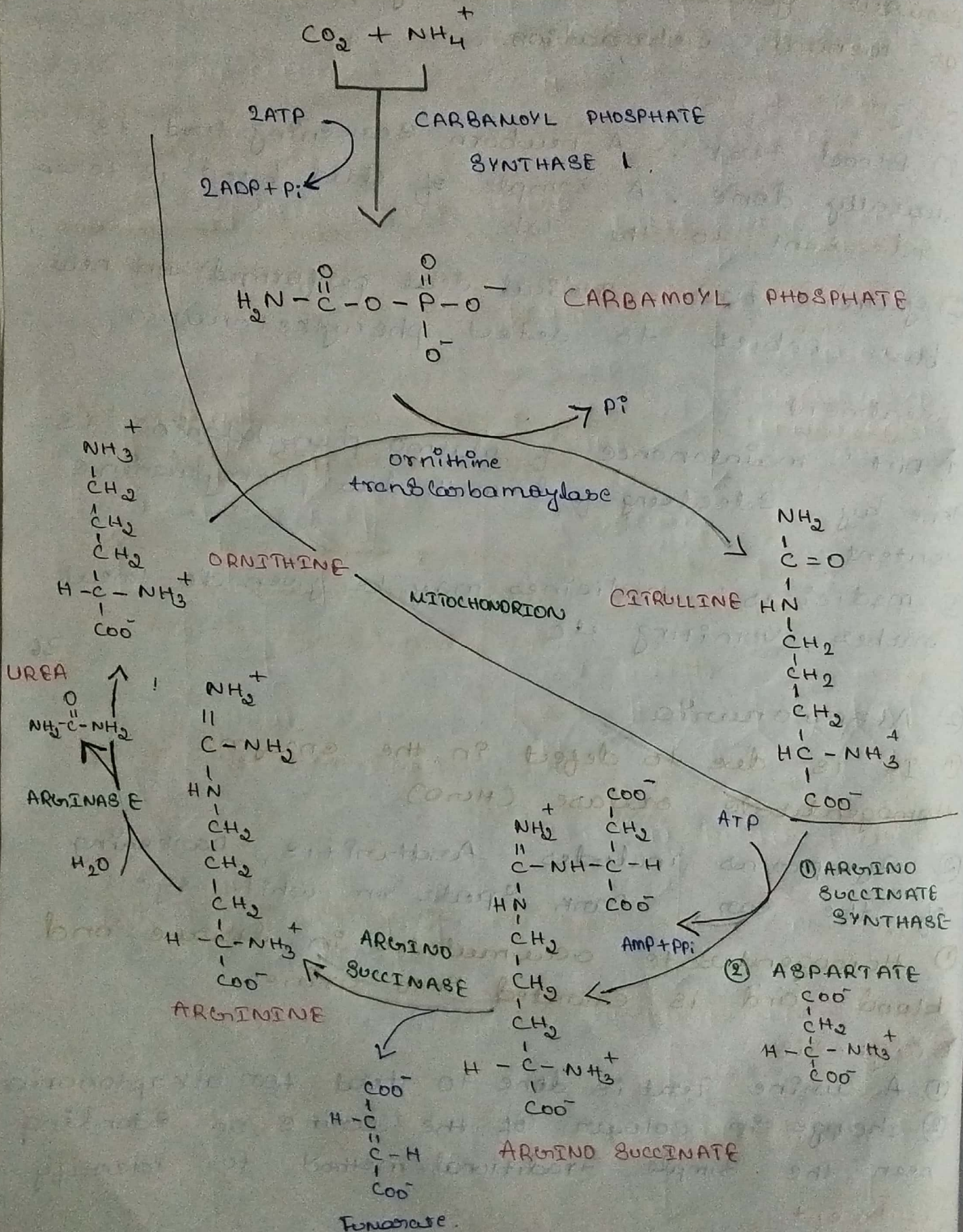
### Treatment

- ① Since it's not a dangerous disorder doesn't require any specific treatment, consumption of protein diet with low phenylalanine content is recommended.



19. Describe the reactions of urea cycle?

12





① urea is the end product of protein metabolism  
② urea is synthesized in liver and transported to kidney for excretion in urine

③ It is a five step cyclic process, with five distinct enzymes. The first two are present in mitochondria while the next are localized in cytosol

④ Synthesis of carbamoyl phosphate:

① carbamoyl phosphate synthase 1 catalyses the condensation of  $\text{NH}_4^+$  and  $\text{CO}_2$  to form carbamoyl phosphate.  
② This step consumes 2 ATP & irreversible

⑤ Formation of citrulline

① citrulline is synthesized from carbamoyl phosphate and ornithine by ornithine transcarbamoylase

⑥ Synthesis of Argininosuccinate

① Argininosuccinate synthase condense citrulline with aspartate to produce argininosuccinate  
② This step requires ATP which cleaved to AMP &  $\text{PPi}$

⑦ Cleavage of argininosuccinate

① Argininosuccinase cleaves argininosuccinate to give arginine and fumarate

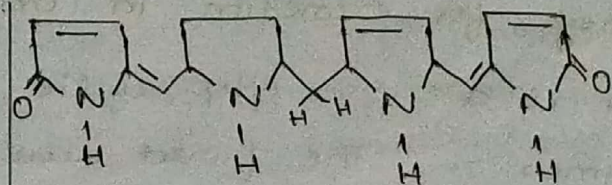
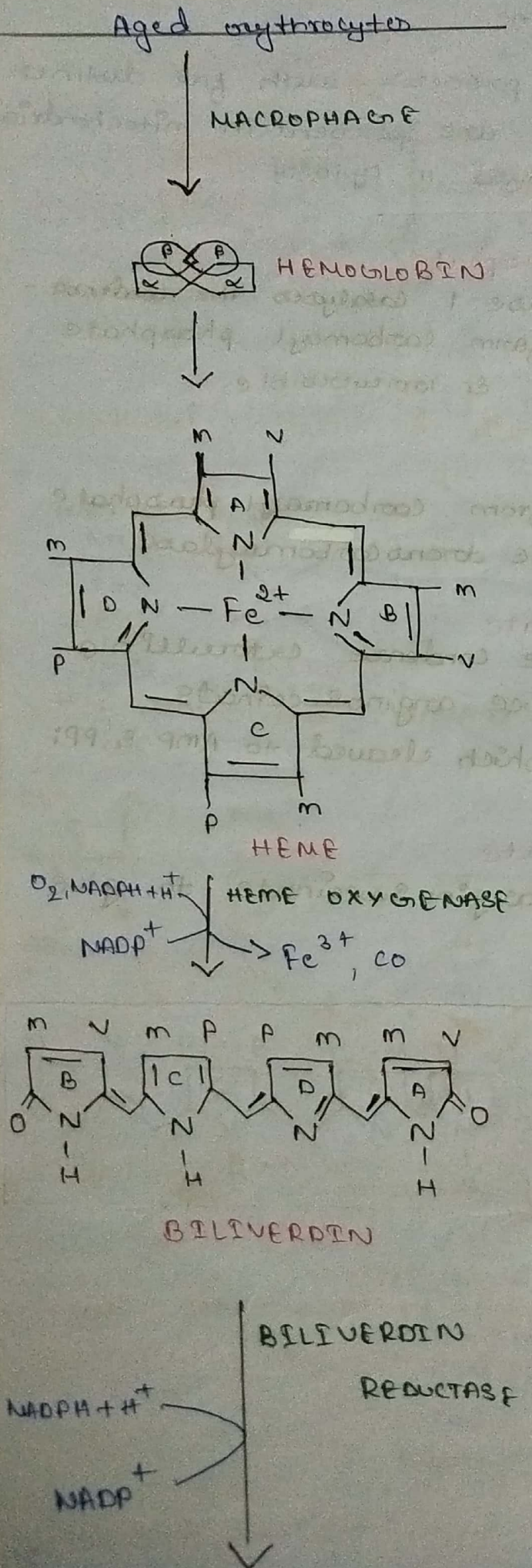
⑧ Formation of urea

① Arginase cleaves arginine to yield urea and ornithine

② ornithine is regenerated



②0 Explain the production of bile pigments?



BILIRUBIN

BLOOD

BILIRUBIN - ALBUMIN  
COMPLEX

LIVER

BILIRUBIN

2 GDP-

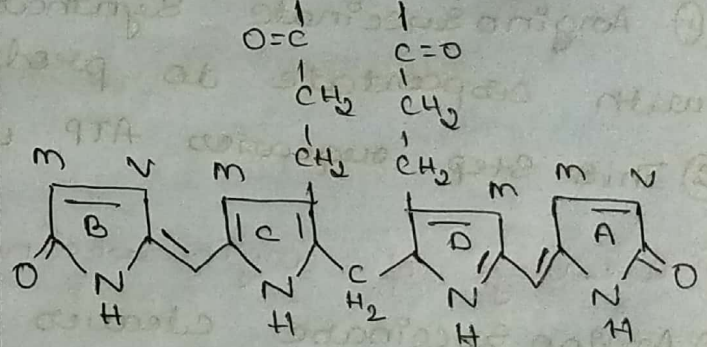
26DP

BILIRUBIN

GALACTURONYL  
TRANSFERASE

glucuronic  
acid

glucuronic  
acid



BILIRUBIN DIGLUCURONIDE

KIDNEY

# MICROBIAL ENZYME

UROBLINOWEN

## MICROBIAL ENZYME

KIDNEY

UROBILIN

STRECOBELIN

TO URINE

TO 78083



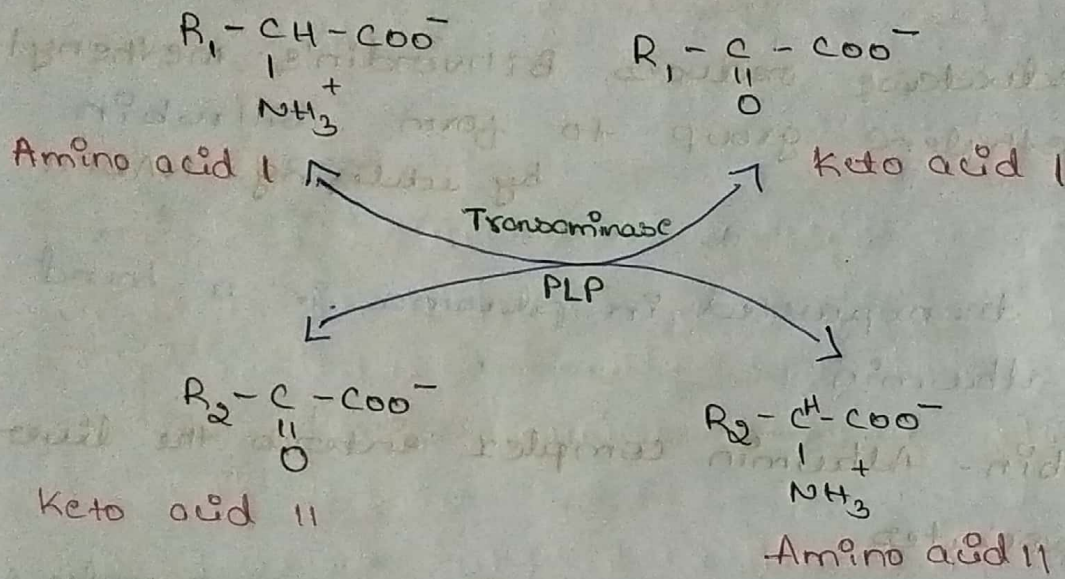
- ① Erythrocytes have a life span of 120 days. At the end of this period, they are removed from the circulation.
- ② Erythrocytes are taken up and degraded by the macrophages.
- ③ The hemoglobin is cleaved to the protein part globin and non-protein part heme.
- ④ Heme oxygenase utilizes NADPH and  $O_2$  and cleaves the methenyl bridges b/w two pyruvate rings to form biliverdin. &  $Fe^{2+}$  is oxidized to  $Fe^{3+}$ .
- ⑤ Biliverdin reductase reduces Biliverdin's methenyl bridges to methylene group to form bilirubin by utilizing NADPH.
- ⑥ Bilirubin is transported in plasma in a bound form with albumin.
- ⑦ As Bilirubin-Albumin complex enters the liver, Bilirubin dissociates.
- ⑧ In liver Bilirubin is conjugated with two molecules of glucuronate. It is catalysed by Bilirubin glucuronyl transferase. It results in formation of Bilirubin diglucuronide.
- ⑨ Bilirubin diglucuronides are hydrolyzed by microbial enzyme to liberate urobilinogen.
- ⑩ Urobilinogen is converted to urobilin in the kidney and excreted. Characteristic colour is due to urobilin.
- ⑪ A major part of urobilinogen is converted by microbial enzyme to stercobilin which is excreted along feces.



② Explain the transamination reactions involved in the catabolism of amino acids.

Ans:

- ① The transfer of Amino group from an amino acid to a keto acid is known as transamination.
- ② This process involves the interconversion of a pair of amino acids and a pair of keto acids catalysed by a group of enzymes called transaminases.



Salient features

- ① Transamination is reversible.
- ② No free  $NH_3$  liberated, only the transfer of amino group.
- ③ All transamination reactions require pyridoxal phosphate (PLP).

Transamination occurs in two stages

- ① Transfer of the amino group to the coenzyme PLP to form pyridoxamine phosphate.
- ② The amino group of pyridoxamine phosphate is then transferred to a keto acid to produce a new amino acid and enzyme PLP is regenerated.

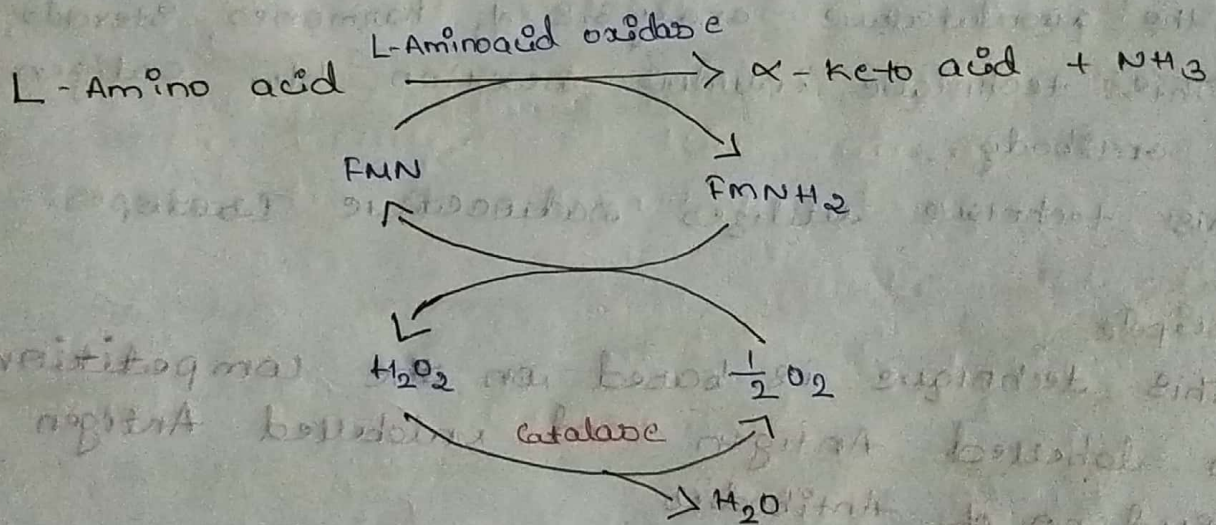


22 Explain the deamination reactions involved in the catabolism of amino acid? 17

- Ans: ① The removal of amino group from the amino acid as  $\text{NH}_3$  is deamination
- ② The carbon skeleton of amino acid is converted to keto acid
- ③ Deamination may be oxidative or non-oxidative

### I oxidative deamination

- ① It is the liberation of ammonia from the amino acids coupled with oxidation.
- ② L-Amino acid oxidase act on L-Amino acid to produce  $\alpha$ -keto acids and  $\text{NH}_3$
- ③ Oxygen is reduced to  $\text{H}_2\text{O}_2$ , which is later decomposed by catalysis.

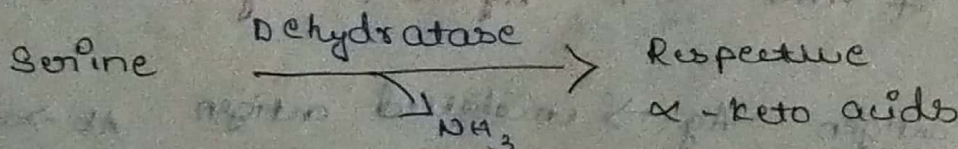


### II Non-oxidative deamination

- ① Some of the amino acids can be deaminated to liberate  $\text{NH}_3$  without undergoing oxidation

#### ① Amino acid dehydratase

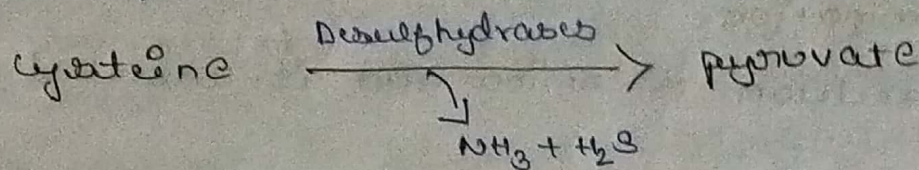
Serine undergo non-oxidative deamination catalysed by dehydratase





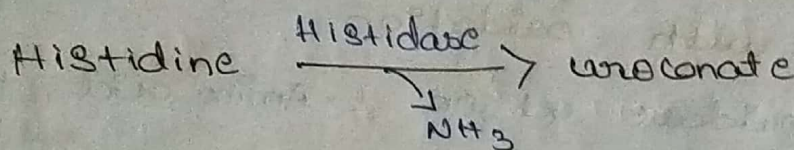
## ② Amino acid desulfhydrases

Cysteine undergo non-oxidative decarboxylation catalysed by desulfhydrases



## ③ Decarboxylation of Histidine

Histidine undergo non-oxidative decarboxylation catalysed by Histidase



## ②3 What is Radioimmuno assay ? Give its principle & Application

Ans ① It is the technique used in the clinical field for the quantitative analysis of hormones, steroids, drugs.

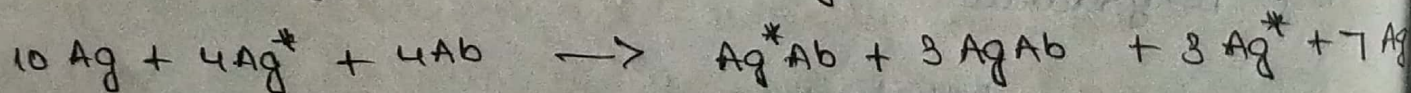
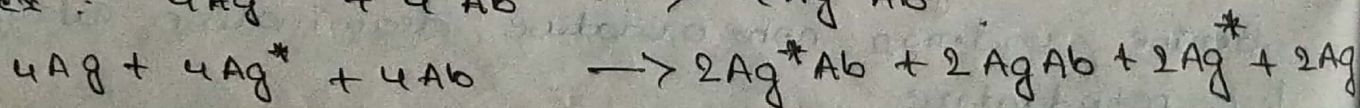
② This technique involves reaction b/w antigen and antibody.

③ This technique utilizes radioactive isotopes

### Principle

① This technique is based on the competition b/w labelled Antigen and unlabelled Antigen for limited no of Antibodies.

② Under standard condition, the amount of labelled antigen bound to the antibody will decrease as the amount of unlabelled antigen increase

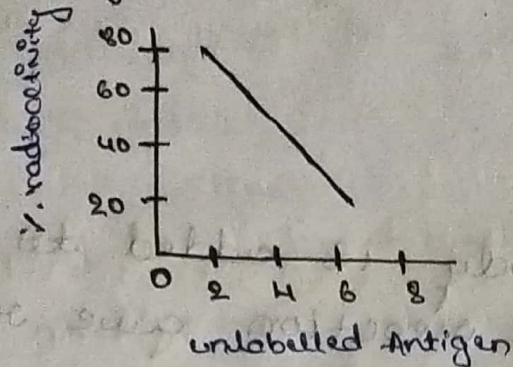


$\text{Ag}^* \rightarrow$  labelled antigen     $\text{Ag} \rightarrow$  unlabelled antigen     $\text{Ab} \rightarrow$  antibody



③ In the above ex, no of antibody and labelled antigen is kept constant only the number of unlabelled antigen is increased. The same principle is followed in the assay system.

④ A standard curve is constructed by performing the assay.



Radioactivity of labelled antigen is inversely proportional to the unlabelled antigen concentration. (Antigens)

⑤ using the above graph, the amount of unlabelled antigen in the serum sample is estimated.

Application.

- ① used to estimate Hormones like  $T_3$  &  $T_4$ , Insulin, menin, aldosterone, FSH, LH etc in the serum sample.
- ② used to estimate Tumour markers like PSA & AFP
- ③ To estimate vitamins
- ④ To estimate Drugs like Digoxin.



Q9) What is ELISA? Explain its principles and application.

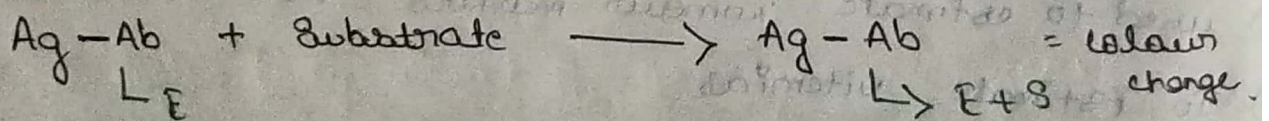
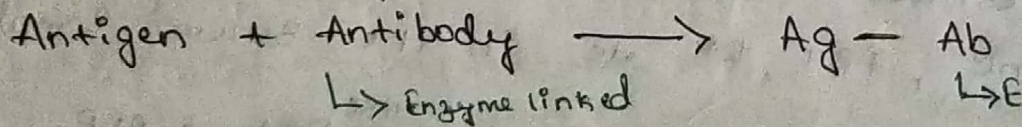
Ans: It is the technique used to detect the Antigen present in serum sample.

Types

- ① Single Antibody method
- ② Double Antibody method

principle

- ① Enzyme linked Antibody, is added to Antigen in serum sample, on reaction give rise to Antigen Antibody complex.
- ② Then Substrate added will react with Enzyme which is attached to antibody, ultimately Substrate - enzyme reaction takes place and it will show colour change.
- ③ changed colour will be analysed under calorimetry in a specified wavelength, to get quantity of particular antigen.



Application.

- ① used to estimate hormones like  $T_3$ ,  $T_4$ , insulin, renin, aldosterone, FSH, LH etc in the serum sample.
- ② used to estimate Tumour markers like PSA & AFP.
- ③ used for the assay of antibody in serum.
- ④ used for the assay of autoantibody.  
Eg: anti-DNA.



35 Enlist different liver function test & Explain  
dye test for Excretory function of liver

Ans. Liver function tests

① Tests based on Excretory function

① serum bilirubin

② urine bilirubin

③ urine urobilinogen

④ urine bile salts

⑤ Dye Excretion Test

② Tests based on Detoxification Function

① Hippuric acid test

② Determination of blood ammonia

③ Tests based on Synthetic function

① plasma proteins

② prothrombin time

④ Tests based on Metabolic function

① galactose tolerance test

② serum cholesterol

③ serum proteins

① Dye Excretion Test

① Bromo Sulphthalein is a dye used to assess the  
Excretory function of liver

② It is a non-toxic compound, exclusively  
excreted by the liver

③ BSP is administered Intravenously & its serum  
concentration is measured at 45 min & at 2 hrs

④ In normal individuals, <5% of the dye is  
retained at the end of 45 min

⑤ Any impairment in liver function causes an  
increased retention of the dye.



26. Discuss the test to assess the metabolic and detoxification capacity of liver

① Hippuric acid test.

① The liver removes benzoic acid by conjugating it with glycine to form hippuric acid which is excreted in the urine

② This test depends on ability of the liver to produce sufficient amount of glycine to conjugate it with Benzoic acid.

procedure.

① About 5g of Benzoic acid is given orally

② In oral test around 3.5g of sodium benzoate should be excreted as hippuric acid in 4hr urine sample in normal person.

③ Less than 3.5g Indicates hepatic dysfunction due to decreased synthesis of glycine

② Galactose tolerance test

① The liver function is assessed by measuring utilization of galactose

② Normal liver converts galactose to glucose, this function is impaired in hepatic dysfunction and the amount of blood & urine galactose is excessive

procedure

① About 300mg/kg body weight of galactose is given Intravenously.

② blood is withdrawn at 10min intervals for 2 hrs. then galactose is estimated

③ Amount of galactose is elevated in hepatocellular damage.



Q. mention different kidney function tests & Explain any two. [NPN constituent Answer]

Ans. Renal function Tests

① glomerular function tests

(i) urea clearance

(ii) creatinine clearance

(iii) Insulin clearance

② Tubular function tests

③ Analysis of urine

④ Analysis of blood

① creatinine clearance Test

It is defined as the volume of plasma that would be completely cleared of creatinine per minute.

Method.

① After giving water, 24 hour urine collection is made

② The volume of urine is recorded, creatinine content in plasma and urine are estimated.

③ The creatinine clearance can be calculated by using formula

$$C = \frac{U \times V}{P}$$

U - creatinine conc in urine

V - vol of urine

P - creatinine conc in plasma

④ The normal range of creatinine clearance is around 120-145 ml/min

⑤ Decrease in creatinine clearance is an indicator of renal damage.



### ③ urea clearance Test

It is defined as volume of plasma that would be completely cleared of urea per minute

#### Method,

- ① After giving water, urine collection is made per minute.
- ② The volume of urine is recorded
- urea content in plasma and urine are estimated.
- ③ The urea clearance can be calculated by using formulae  $C_m = \frac{U \times V}{P}$   $C_m \rightarrow$  Maximum urea clearance
- ④ The normal value of maximum urea clearance is 75 ml/min
- ⑤ Decrease in urea clearance is an Indicator of renal damage.

### ⑫ Discuss Biochemical role & deficiency symptoms of $B_2$ & $B_6$

#### ① Vitamin $B_2$ [Riboflavin]

##### ① Biochemical role

- ① Riboflavin helps in breakdown of protein, fats & carbohydrates.
- ② It helps to convert carbohydrates into ATP.
- ③ It plays vital role in maintaining the body's energy supply.
- ④ The flavin co-enzyme participate in many Redox reaction.



## (ii) Deficiency Symptoms

- (1) Inflammation of lips.
- (2) Inflammation of Tongue.
- (3) Mouth ulcers.
- (4) Redness of eyes.
- (5) Itching of eyes.

## (2) Vitamin B<sub>6</sub> [Pyridoxine]

### (1) Biochemical role.

- (1) B<sub>6</sub> acts as co-enzyme for glycine Synthase.
- (2) pyridoxal phosphate [PLP] is a co-enzyme closely associated with metabolism of amino acids.
- (3) It plays important role in synthesis of serotonin, histamine, niacin co-enzymes.
- (4) PLP involves in reaction like transamination, decarboxylation etc.

### (ii) Deficiency Symptoms

- (1) Anemia
- (2) Nerve damage.
- (3) mental confusion
- (4) loss of appetite, nausea
- (5) weakness, sleeplessness



## 29) Biochemical role and deficiency symptoms

of B<sub>1</sub> & folic acid

(i) Vitamin B<sub>1</sub> [Thiamine]

(i) Biochemical role

write B<sub>2</sub> first two points

(1) Thiamine enables the body to use carbohydrates as energy.

(2) It is essential for glucose metabolism.

(3) It plays an important role in transmission of nerve impulses.

(4) It plays key role in muscle and heart function.

(ii) Deficiency symptoms

(1) Beriberi

(2) mental confusion

(3) loss of appetite (Anorexia), nausea

(4) weakness, sleeplessness

(2) Folic acid

(i) Biochemical role

(1) It involves in synthesis and repair of DNA & RNA.

(2) It involves in Regulation of gene expression

(3) It aids rapid cell division & growth

(4) It involves in RBC production and nervous system development

write B<sub>12</sub>

2nd two points

(ii) Deficiency symptoms

(1) Anemia

(2) possible problem with memory & brain function

(3) low bone density

(4) allergic diseases

(5) congenital deformities



## 30) Biochemical & Deficiency Symptom of vit B<sub>12</sub>

① vitamin B<sub>12</sub> [Cobalamin]

② Biochemical role

- ① Synthesis of methionine from homocysteine
- ② Isomerization of methylmalonyl CoA to Succinyl CoA
- ③ It plays important role in production of RBC
- ④ It is needed for nerve tissue health & brain function.

③ Deficiency Symptom

- ① Anemia
- ② Depression, Confusion
- ③ Memory problem
- ④ Nerve & brain damage
- ⑤ Loss of appetite
- ⑥ weight loss
- ⑦ fatigue
- ⑧ Constipation



## Q1) Add a note on role of kidney

### ① urine formation

Formation of urine in kidney involves three processes

① glomerular filtration :- Filtration of water, salts and other substances occurs in glomeruli

② Tubular secretion :- Substances present in excess in blood are eliminated by this process

③ Tubular reabsorption :- Reabsorption of water, salts and other substances occurs in convoluted tubule & collecting duct.

### ② Regulation of pH

Kidney regulates extracellular fluid  $H^+$  conc through three fundamental mechanisms

i) Secretion of  $H^+$

ii) Reabsorption of filtered  $HCO_3^-$

iii) production of new  $HCO_3^-$

### ③ production of Hormones

① It acts as target organ for many hormones like ADH and aldosterone

② It acts as endocrine organ by secreting hormones like Renin, & Erythropoietin.

### ④ Excretion of NPN products of metabolism

urea, uric acid and creatinine are the substances excreted by kidney



Q2) Write the composition & functions of lipoprotein

Composition

- ① Lipoprotein core consists of
  - i) Triglycerides
  - ii) cholesterol esters
- ② Lipoprotein surface consists of
  - i) phospholipids
  - ii) protein
  - iii) cholesterol

Functions -

- ① HDL collects cholesterol from non-hepatic tissues and delivers to the liver.
- ② LDL collects cholesterol from liver synthesis and delivers to the various tissues.
- ③ VLDL collects cholesterol from liver synthesis and delivers to the non-hepatic tissues.
- ④ chylomicrons deliver dietary cholesterol to the liver.
- ⑤ It helps the body to sustain its nerve cells and other vital cells in the body.
- ⑥ It also helps the lipids to transport energy to the muscles.



### ③ Add a note on HDL & LDL

- ① LDL (Low density lipoproteins)
- ① It is synthesized from IDL (Intermediate density lipoproteins)
- ② Its half life is 2 days
- ③ LDL is a bad cholesterol

#### Function

- ① LDL collects cholesterol from liver synthesis and delivers to the various tissues

#### Clinical Significance

- ① LDL concentration is increased in cardiovascular disease

### ④ HDL (High density lipoprotein)

- ① It is synthesized in the liver
- ② Reservoir of apoproteins
- ③ HDL is a good cholesterol

#### Function

- ① HDL collects cholesterol from non-hepatic tissues and delivers to liver

#### Clinical Significance

- ① Serum HDL levels are inversely related to incidence of MI.
- ② HDL is "atheroprotective" in nature



34) write a note on urinary tract calculi.  
urinary calculi.

It means stones in urinary tract that occurs due to high concentration of dissolved minerals in urinary tract.

Etiology

- ① Increased calcium level
- ② Elevated uric acid
- ③ low fluid intake
- ④ high minerals in drinking water
- ⑤ obstruction of urinary tract

Pathophysiology

- ① Due to etiological factor, conc of stone forming crystal in urinary tract increases.
- ② Growth continues by aggregation of particles, results in formation of larger stone.

Clinical Manifestation

- ① Severe abdominal pain
- ② Discomfort
- ③ Nausea & vomiting
- ④ Painful urination

Diagnosis

- ① X-ray
- ② Urine analysis
- ③ Serum calcium & uric acid level

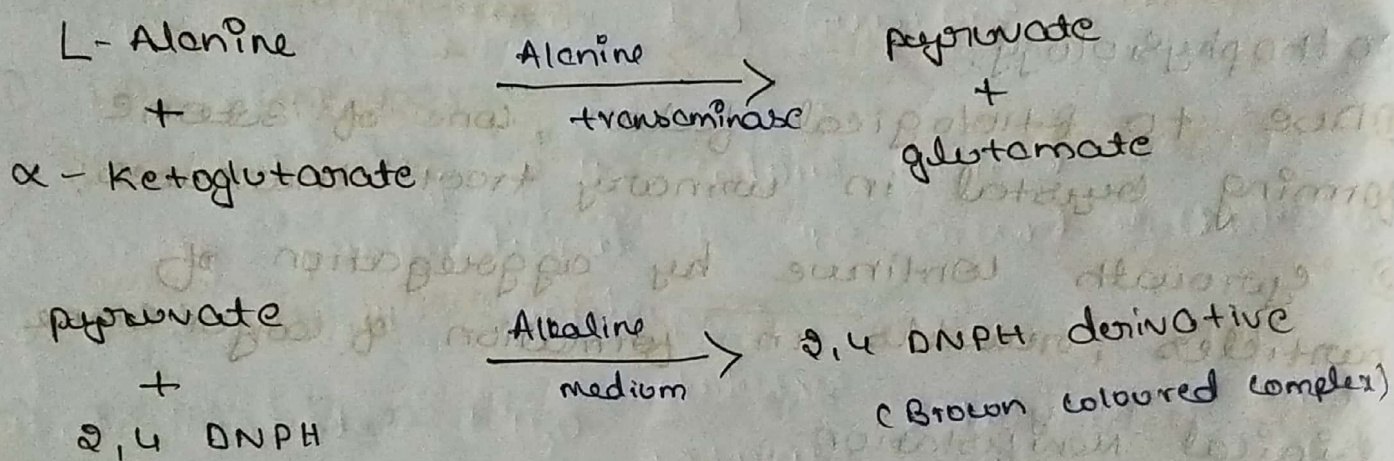


Q5) write the principle & significance of  
SGPT & SGOT determination

① SGPT

Principle

- ① Alanine Transaminase converts L-alanine &  $\alpha$ -ketoglutarate to pyruvate and glutamate.
- ② The pyruvate formed react with 2,4 DNPH to produce 2,4 DNPH derivative, a brown coloured complex in alkaline medium whose intensity is measured at 505 nm.



Clinical Significance.

- ① Alanine transaminase is mainly found in the liver.
- ② So elevation in serum alanine transaminase is relatively specific for liver diseases.
- ③ Increased levels are found in hepatitis, liver cirrhosis, obstructive jaundice.

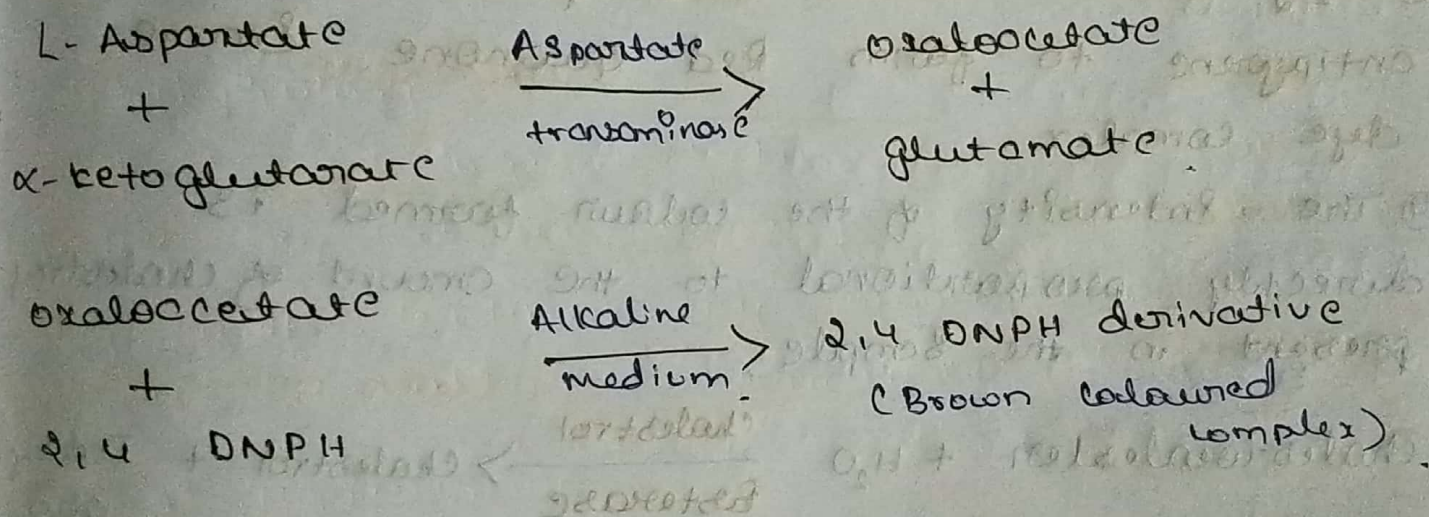


## ① AST

### principle

① Aspartate transaminase converts L-Aspartate &  $\alpha$ -keto glutarate to oxaloacetate & glutamate

② The oxaloacetate formed react with 2,4 DNPH to produce a 2,4 DNPH derivative, a brown coloured complex in alkaline medium whose intensity is measured at 505 nm.



### Clinical Significance

- ① Aspartate transaminase is mainly found in liver, Heart & Skeletal Muscles.
- ② Elevated levels are found in myocardial infarction, hepatitis, liver cirrhosis.
- ③ decreased levels are found in pregnancy & Biliary.



Q6 Determination of total cholesterol in Serum / describe lipid profile test.

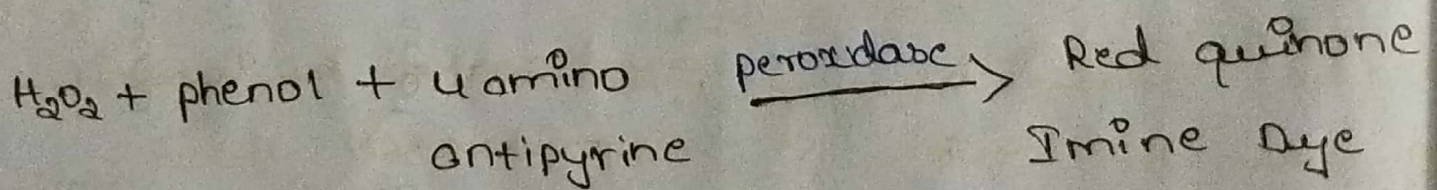
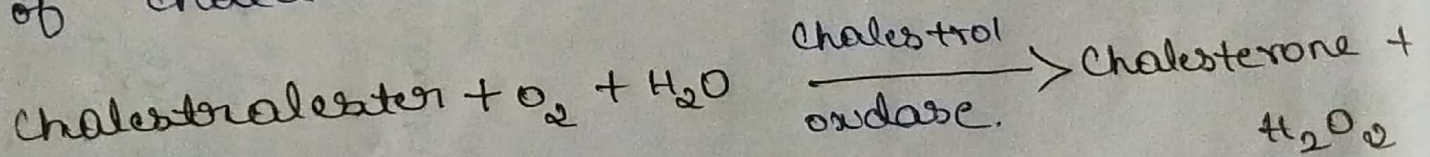
Ans: Determination of Serum <sup>total</sup> cholesterol by CHOD PAP method

Principle.

① Cholesterol is oxidized to cholesterolone and  $H_2O_2$  in presence of cholesterol oxidase

②  $H_2O_2$  further reacts with phenol and 4-aminoantipyrine to form Red quinone Imine dye.

③ The Intensity of the colour formed is directly proportional to the amount of cholesterol present in the sample.



Significance

lipid profile test

① total cholesterol

② LDL

③ HDL.



# procedure

| Sl No. | Reagents              | B    | S    | T    |
|--------|-----------------------|------|------|------|
| ①      | cholesterol reagent   | 2    | 2    | 2    |
| ②      | Dist H <sub>2</sub> O | 0.02 | —    | —    |
| ③      | cholesterol std       | —    | 0.02 | —    |
| ④      | Sample Solution       | —    | —    | 0.02 |

Mix well and allow to stand for 10 min  
then measure absorbance at ~~510~~ 510 nm

## ③ Determination of LDL cholesterol by enzymatic method

### Principle

- ① LDL cholesterol is precipitated by heparin
- ② when the tube is centrifuged LDL - cholesterol separates at the bottom, supernatant contains HDL & VLDL
- ③ Supernatant is tested enzymatically for cholesterol concentration.
- ④ LDL is calculated as -  

$$\text{LDL cholesterol} = \text{Total cholesterol} - \text{cholesterol present in supernatant}$$



③ Determination of HDL cholesterol by Enzymatic method

① Chylomicrons, VLDL, LDL present in serum are ppt'd by polysions. cholesterol esters left behind.

① Cholesterol ester is oxidized to cholesteroone and  $H_2O_2$  in presence of cholesterol oxidase.

②  $H_2O_2$  further reacts with phenol & 4 amino antipyrine to form red-quinone imine dye complex.

③ The intensity of the colour formed is directly proportional to the amount of cholesterol present in the sample.

37) Name the Importance of phospholipids?  
give their physiological role.

Importance

① Phospholipids are compound lipids containing phosphoric acid & fatty acid.

② There are two classes of phospholipids

① glycerophospholipids

② sphingophospholipids

③ Glycerophospholipids are major lipids that occurs in biological membrane.

④ Sphingophospholipids are important constituents of nervous tissues.



physiological role.

- ① phospholipids in mitochondria maintain the conformation of electron transport chain components.
- ② They participate in the absorption of fats from intestine.
- ③ They are essential for synthesis of different lipoprotein.
- ④ They prevent accumulation of fat in liver.
- ⑤ They participate in blood clotting.



2 mark important concepts



## Enzymes

① what are allosteric enzymes? give two examples

Ans: Some of the enzymes possess additional sites known as allosteric sites, besides the active site. Such enzymes are known as allosteric enzymes.

Ex: HEXOKINASE

PHOSPHOFRUCTOKINASE

② give Michaelis-Menten eq with notations used

$$V = \frac{V_{max} \cdot [S]}{K_m + [S]}$$

$V$  → measured velocity  
 $V_{max}$  → maximum velocity  
 $[S]$  → substrate concentration  
 $K_m$  → Michael-Menten constant

③ give therapeutic uses of any two enzymes

- ① Streptokinase → Heart attacks (clot buster)
- ② Asparaginase → Acute childhood Leukemia (↓ level of serum asparagine)



(4) what is Line - weaver Burk plot ? give its significance ?

Ans From the determination of  $K_m$  value the substrate saturation curve is not very accurate since  $V_{max}$  is approached asymptotically. By taking the reciprocals of the equation, a straight line graphic representation is obtained

- ① It is much easier to calculate  $K_m$  value
- ② It is useful in understanding the effects of various inhibitions.

(5) what is  $V_{max}$ , give significance

Ans: It is the maximum rate of reaction when the enzyme is saturated with substrate

- ① It reveals turnover no of an enzyme
- ②

(6) Define  $K_m$  write its significance

Ans It is defined as substrate concentration to produce half maximum velocity in an enzyme catalysed reaction.

- ① It represents strength of ES complex



⑦ what are the two models to explain the active site of enzymes?

- ① Lock & Key model
- ② Induced fit theory
- ③ Substrate strain theory

⑧ Define enzyme specificity? give ex

Ans It is the ability of the enzyme to choose exact substrate. i.e. which will catalyze only one particular reaction

Ex: Lactase is specific for degradation of lactose  
 Sucrase, which acts on sucrose

⑨ what is Holoenzyme and apoenzyme

Holoenzyme  $\rightarrow$  Apoenzyme + Coenzyme  
 (protein part) (non-protein part)

① The functional unit of enzyme is known as Holoenzyme

② The protein part of Holoenzyme is known as apoenzyme



① what is Diabetes mellitus? Mention its types

Ans Diabetes Mellitus is a clinical condition characterized by increased blood glucose level due to insufficient Insulin

Ex: Insulin dependent (type 1)  
Non-Insulin dependent (type 2)

② 10 galactose tolerance test

Ans, It is a laboratory test done to determine the liver's ability to convert the galactose into glycogen.

③ 15 glucose tolerance test

It is a laboratory test done on the basis of individual response to oral glucose load.

④ 20 Significance of galactose tolerance test



Q1) what is the role of carnitine in fatty acid oxidation?

Ans ① The inner mitochondrial membrane is impermeable to fatty acids.

② ~~Acyl CoA is transformed into carnitine~~

② Carnitine carrier system operates to transport Activated Fatty acids into Mitochondrial Matrix by specific carrier protein

Q2) what is the role of citrate in fatty acid synthesis?

① Citrate is freely transported to cytosol

② It is cleaved by citrate lyase to liberate acetyl CoA

15

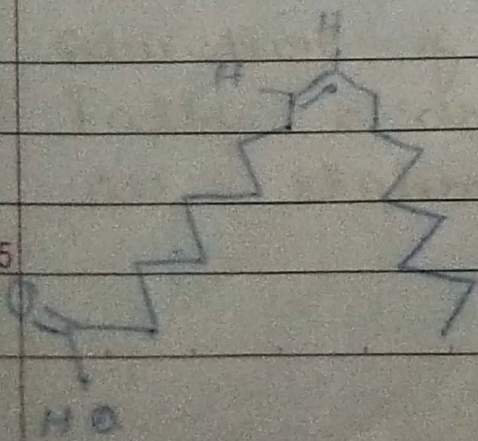
Q3) what is ketosis? Name condition leads ketosis

Ans The ketonemia and ketonuria is commonly referred as ketosis

① 20 Starvation

② Severe uncontrolled Diabetes mellitus

25





Q4) what is ketolysis? give its significance.  
 Ans. The breakdown of ketone bodies is known as ketolysis.

Q5) Ketolysis completes the oxidation of fatty acid which starts in liver.

Q2) It is a major source of energy to extrahepatic tissue during starvation.

Q10) what is the functional significance of Fatty acid Synthase complex?

Q1) The FAS complex offers great efficiency that is free from interference of other cellular reactions.

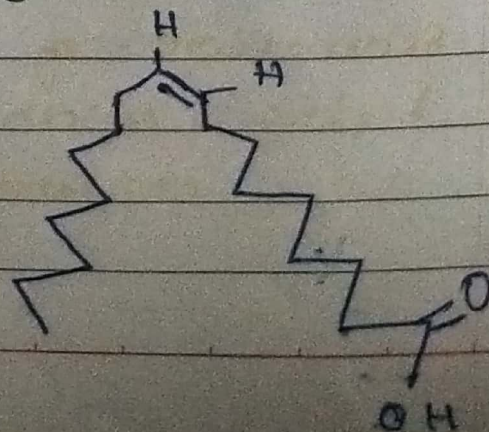
Q15) Entire process of metabolic pathway is confined to the complex. Hence there is no permeability barriers for various intermediates.

Q6) Name three unsaturated Fatty acids.  
 Write the structure of one of them.

Q1) oleic acid

Q2) palmitoleic acid

Q3) vaccenic acid





⑦ Enumerate the function of unsaturated fatty acid.

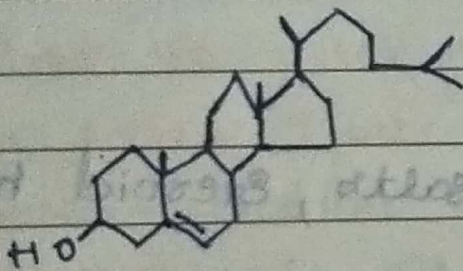
- ① It reduces cholesterol in the blood
- ② It is also good for brain function.

5

⑧ Write the structure of cholesterol, what is the role of cholesterol in our body?

Sol.

15



- ① It is a structural component of cell membrane
- ② Cholesterol is the precursor for the synthesis of steroids in the body.
- ③ It is an essential ingredient in the structure of lipoprotein
- ④ Fatty acids are transported to liver as cholesterol esters.

25



Q. What are bile salts? Give their importance.

Ans. In the bile, conjugated bile acids exist as sodium and potassium salts which are known as bile salts.

5

① They are important for digestion and absorption of fats.

② They stimulate liver cell to secrete more bile.

③ They prevent precipitation of cholesterol.

10. Name three biologically important compounds derived from the catabolism of cholesterol.

15

Ans. Vitamin D, Bile salts, steroid hormone

Q. What is hypercholesterolemia?

Name two disorders results from this.

Ans. Increased concentration of plasma cholesterol is known as hypercholesterolemia.

① Diabetes mellitus

② Hypothyroidism.

Ex: Jaundice for hypocholesterolemia



(12) What are the two measures that can be used to prevent hypercholesterolemia?

① Consumption of PUFA :- Dietary intake of polyunsaturated fatty acids reduces plasma cholesterol level.

② Dietary cholesterol :- Avoidance of cholesterol rich food.

③ Avoiding high-carbohydrate diet - Diets rich in carbohydrates should be avoided.

(13) What is fatty liver? Two causes responsible for fatty liver.

Ans Accumulation of triacylglycerol (TG) in the liver is known as Fatty liver.

① Increased Synthesis of triacylglycerols

② Impairment in lipoprotein synthesis

(14) Atherosclerosis

① It is complex disease characterized by hardening of arteries due to accumulation of fats in the inner arterial wall.



⑩ It is progressive disorder that narrows and ultimately blocks the arteries which leads to myocardial infarction.

## ⑪ acidosis and alkalosis

### Acidosis

① It is defined as decline in blood pH.

Metabolic - Due to decrease in  $\text{HCO}_3^-$  ions  
acidosis.

Respiratory - Due to increase in carbonic acid.  
acidosis.

### Alkalosis

① It is defined as rise in blood pH.

Metabolic - Due to increase in  $\text{HCO}_3^-$  ions  
alkalosis.

Respiratory - Due to decrease in carbonic acid.  
alkalosis.



46 clinical manifestation in  
water depletion water excess

- |                                                                                                                                                                    |                                                                                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>①<sub>5</sub> Skin turgor</p> <p>② Dry mucous membrane</p> <p>③ dehydration</p> <p>④ Stomach pain</p> <p>⑤ urine disorder</p> <p>⑥<sub>10</sub> tachycardia</p> | <p>① kidney disease</p> <p>② Heart failure</p> <p>③ lung disease</p> <p>④ liver disease</p> <p>⑤ thyroid disease</p> <p>⑥ allergic reaction</p> <p>⑦ autoimmune disease</p> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

①<sub>7</sub> What are causes of water depletion

15

- |                                                                                                                                                                                                                                                                                                                                                               |          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <p>① Severe diarrhoea and vomiting</p> <p>② non-availability of drinking water as in case of desert condition</p> <p>③ loss of fluid from skin in case of burn</p> <p>④ Heart stroke</p> <p>⑤ Excitement</p> <p>⑥ Difficulty in swallowing &amp; in state of unconsciousness</p> <p>⑦<sub>25</sub> Sweating</p> <p>⑧ Diabetes</p> <p>⑨ frequent urination</p> | <p>①</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|



## (18) water excess (causes)

- (1) Hypersecretion of ADH
- (2) In case of Renal failure
- (3) SIADH Syndrome (Inappropriate ADH Secretion)
- (4) Medications

## (19) Composition of ORS

|                    |       |
|--------------------|-------|
| Sodium chloride    | 1.0 g |
| potassium chloride | 1.5 g |
| $\text{NaHCO}_3$   | 1.5 g |
| glucose            | 40 g  |

## (20) what is the role of aldosterone in the regulation of osmolality?

(1) When osmolality decreases below the normal, kidney reabsorbs sodium ions in tubules. This is controlled by aldosterone.

(2) When osmolality increases above normal, the aldosterone secretion is inhibited.



## (21) Role of kidney in water balance.

(1) The kidney can adjust the conc of urine to reflect body's water needs.

(2) conserving water if the body is dehydrated, i.e by excreting con urine.

(3) making urine more dilute to expel excess water

(4) ADH is a hormone that helps the body to retain water by increasing  $H_2O$  absorption by the kidney.

## (22) Name the different fluid compartments in the body.

(1) Intravascular compartment

(2) Intracellular compartment

(3) Interstitial compartment



(23) Define hypokalemia and hyponatremia

Hypokalemia

- ① 5 It is defined as decrease in the conc of serum potassium
- ② It is observed due to overactivity of adrenal cortex

10 Hyponatremia

- ① It is defined as decrease in the conc of serum sodium than normal
- ② It occurs due to diarrhoea, vomiting etc

15

(24) How level of calcium determined in the body  
Borophol's method

- ① 20 Calcium in alkaline medium combines with anthracene sulphonic acid to form purple coloured complex



⑨ The Intensity of colour formed is proportional to calcium present in the sample

Calcium + o-cresol

phthalein  
complex

→ purple coloured complex

Sodium  
or

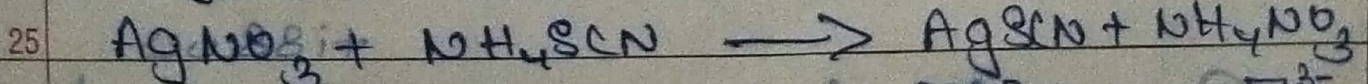
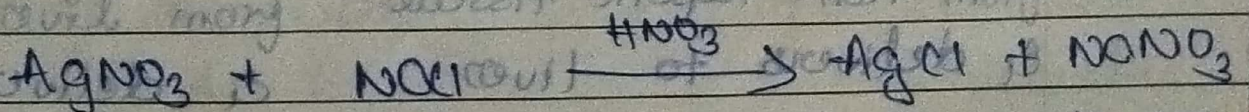
Q10 How level of chlorides are estimated in the body. Volhard's method.

① NaCl when treated with  $\text{AgNO}_3$  &  $\text{HNO}_3$ ,  $\text{AgCl}$  is formed

15

⑤ untreated  $\text{AgNO}_3$  is treated with Ammonium thiocyanate to yield silver thiocyanate

⑥<sub>20</sub> Excess thiocyanate reacts with Ferric ions of Ferric alum to yield Ferric Ferrithiocyanate



Reddish brown colour.



26. Enumerate the function of water

- ① It provides aqueous medium which is necessary for various biochemical reaction
- ② It is reactant in several metabolic reactions
- ③ It serves as vehicle for transport of solutes.
- ④ It regulates body temperature

28. List out lipid profile tests

- ① Total cholesterol
- ② LDL cholesterol
- ③ HDL cholesterol
- ④ Triglycerides

29. Good cholesterol (HDL)      Bad cholesterol (LDL)

20

- |                                                                        |                                                                     |
|------------------------------------------------------------------------|---------------------------------------------------------------------|
| ① High density lipoprotein                                             | ① Low density lipoprotein                                           |
| ② HDL collects cholesterol from non-hepatic tissue & delivers to liver | ② LDL collects cholesterol from liver & delivers to various tissues |
| ③ particle density of molecule is high                                 | ③ particle density of molecule is low                               |



③ Higher level beneficial for the health.

④ lower level beneficial for the health.

⑤ Level should be 60 mg/dl or above

⑥ levels should be less than 40 mg/dl.

## 20 Triglycerides

## lipoproteins

① produced by the body

① Either produced in the body or come from External source

② Building block of

② serve as energy source

15 cell

③ Normal level in blood should be less than 150 mg/dl

③ Normal level in blood should be less than 200 mg/dl

20

④ Elevated levels leads to cardiovascular diseases

④ Elevated levels leads to cardiovascular diseases

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ous

25





## ③① Significance of lipid profile test.

① Increased level of cholesterol are found in hypercholesterolemia, hypothyroidism

② Decreased level of cholesterol are found in hypothyroidism, malnutrition

③<sub>10</sub> LDL concentration is increased in cardiovascular diseases

④ HDL levels are inversely related to incidence of MI

## ③①<sub>15</sub> Give examples for bile salts & bile pigment

① bile pigment - Bilirubin, Biliverdin

②<sub>20</sub> Bile salts - ① glycocholic acid

② Taurocholic acid

③ Deoxycholic acid

④ glychenodeoxycholic acid

⑤ Lithocholic acid



(33) Normal serum bilirubin level ?  
give its significance

(1) Direct bilirubin = 0.2 mg/100ml

Total bilirubin = 1 mg/100ml

(2) Elevated levels are found in  
hemolytic jaundice, hepatic  
jaundice, obstructive jaundice.

(3) It is formed by heme portion of  
aged erythrocytes.

(4) Water soluble bilirubin complex  
is known as direct bilirubin.

(5) Water insoluble bilirubin complex  
is known as indirect bilirubin.

(34) Name any four abnormal urine  
constituents

(1) Blood

(2) Bile salts

(3) Bile pigments

(4) proteins

(5) Leucocytes

(6) ketone bodies



## (35) urea & creatinine clearance test

### urea clearance test

① It is defined as volume of plasma that would be completely cleared of urea per minute

② The normal value of maximum urea clearance is 75 ml/min

③ Decrease in urea clearance is an indicator of renal damage

### creatinine clearance test

①<sup>15</sup> It is defined as volume of plasma that would be completely cleared of creatinine per minute

② The normal range of creatinine clearance is around 120 - 145 ml/min

③ Decrease in creatinine clearance is an indicator of renal damage



## 36 Semi quantitative urine analysis

① In semi quantitative examination urine is not diluted.

5

② These examinations are less in laboratories and also less accurate.

③ 10 What is urine concentration test give its significance.

① It is a test to assess the renal tubular function.

② 15 It is simple test & involves accurate measurement of specific gravity which depends on concentration of solutes in urine.

## 20 Clinical Significance

① used to evaluate urinary tract infection, dehydration, kidney failure, heart failure, other hormone problems etc

25